COMPUTERS, CHILDREN AND CLASSROOMS:

A Multisite Evaluation of the Creative Use of Microcomputers by Elementary School Children

HILDA W. CARMICHAEL, Principal Investigator

J. DALE BURNETT
WILLIAM C. HIGGINSON
BARBARA G. MOORE
PHYLLIS J. POLLARD

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It reflects the views of the authors and not necessarily those of the Ministry.

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Education

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A MULTISITE EVALUATION OF THE CREATIVE USE OF
MICROCOMPUTERS BY ELEMENTARY SCHOOL CHILDREN

Hilda W. Carmichael, J. Dale Burnett, William C. Higginson
Barbara G. Moore, Phyllis J. Pollard

FINAL REPORT

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Onteris Abstract

This study examines the creative uses of computers in elementary schools and their impact on students' confidence and self-esteem, student-student interaction, student-teacher interaction, male and female students, classroom management, the role of the teacher, special education, teacher training, other members in the school, and curricular areas such as computer literacy, learning Logo as a programming language, problem-solving and problem-creation, mathematics, oral communication, reading and writing, the arts, and values and the individual in society. Findings are based on intensive study of real classrooms over a two-year period. 433 students in eighteen classrooms that involved 13 different teachers were studied over the two year period; of these, five teachers and 40 students were involved in the study for two years. Classrooms had constant use of one to five computers over the entire school year or students had access to a computer laboratory. Logo and word processing were studied extensively; the use of a graphics tablet and Musicland were explored for short periods. The report discusses in detail the various software that was used and offers extensive illustrations of what children from Kindergarten to Grade eight were able to accomplish with them.

Abstract

This study examines the creative uses of computers in elementary schools and their impact on students' confidence and self-esteem, student-student interaction, student-teacher interaction, male and female students, classroom management, the role of the teacher, special education, teacher training, other members in the school, and curricular areas such as computer literacy, learning Logo as a programming language, problem-solving and problem-creation, mathematics, oral communication, reading and writing, the arts, and values and the individual in society. Findings are based on intensive study of real classrooms over a two-year period. 433 students in eighteen classrooms that involved 13 different teachers were studied over the two year period; of these, five teachers and 40 students were involved in the study for two years. Classrooms had one to five computers over an entire school year or students had access to a computer laboratory. Logo and word processing were studied extensively; the use of a graphics tablet and Musicland were explored for short periods. The report discusses in detail the various software that was used and offers extensive illustrations of what children from Kindergarten to Grade 8 were able to accomplish with them.

The most significant finding is that the creative use of microcomputers in education is NOT automated education - it is the very opposite. When the focus is on the development of independent and original thinking, the teacher and the "art" of teaching become critical elements in shaping the learning environment. Also the role of the teacher in such an environment is different, since the teacher is expected to deal with the unknown and unexpected as problems and questions arise. It was found that Logo is a highly adaptable language which made it possible to explore certain mathematical concepts in a different sequence and much earlier than is currently believed. Problem solving is an integral part of programming and of creative expression. The use of a word processor greatly aided language development and the use of graphics tablets aided artistic expression, especially in the younger grades where the mechanics of using a pencil or brush are still a painful process for many students. It was found that an environment that encourages exploration leads to extensive social interaction among students and that students become more willing to express, refine, or revise their ideas. A significantly greater proportion of students experienced an increase in their confidence and self-esteem if their teacher was able to give them greater autonomy over their learning and fostered social interaction. The impact on students' attention span and cognitive development in the special education classes was also significant. Differences in computer usage between boys and girls were observed in one of

the classes. It was found that teachers need strong technical, educational, emotional and social support in coping with changes demanded by the creative use of computers. The principal plays a critical role in giving or fostering such support structures. Additional support is needed from knowledgeable people outside the individual schools. The events chronicled in this report suggest that reviews of the curriculum guidelines need to be made continually as new developments and uses of this technology emerge and as the exposure to computers in the early grades find extensions or repercussions in subsequent years.

Acknowledgements

This project could not have taken place without the support and the co-operation of a large number of people. We would like to acknowledge our indebtedness and gratitude to:

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- Pat Dudley and Rena Upitis who, respectively, carried out the brief studies on LCSI Sprite and Musicland.

NOTE: ALL NAMES OF TEACHERS, STUDENTS AND SCHOOLS REFERRED TO IN THIS REPORT HAVE BEEN CHANGED.

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Introduction

The roots of this project go back to the fall of 1981. A number of circumstances which existed at that time influenced the goals and methodology of the study.

In many educational circles, 1981 was a time of excitement. The media was full of speculation that emerging forms of microelectronic technology, particularly in the shape of computers, would radically alter the structure of our society. It was clear that the nature of these new information-handling machines meant that educational institutions would be among those influenced by these changes. There was, however, very little agreement on how, in what form, or over what time period this postulated change would take place.

The sense of excitement and of anticipation had two faces. One was of hope: the new technology was seen as a potentially powerful tool in helping individuals come to understand the nature of the world, and in escaping some of the more stifling aspects of curriculum organization. Yet, in many ways it was seen as custom-made for depersonalizing education and perhaps even for threatening the existence of teaching as a profession.

The direction that the Ministry of Education wished to see computers take in the Province of Ontario was outlined in Policy/Program Memorandum No. 47, February 1982, entitled: "Computers in Education". In this document it was stated that:

> There will be two fundamentally different ways to use computers in the process of teaching and learning. The more significant way will be the creative use of the computer by individuals: writing, composing, designing, analyzing, and other extensions of original thought. All students must be given opportunities to use computers in this way. The second, and currently the most prevalent way in which computers are used in education, is to gain access to learning materials and information resources.

Two points deserve to be highlighted. The first is that this statement is very much in keeping with other policy statements about Ontario education, such as the 1975 policy document Education in the Primary and Junior Divisions. For example, the first three of thirteen "Goals of Education in Ontario" are: "(1) Develop a responsiveness to the dynamic processes of learning, (2) Develop resourcefulness, adaptability, and creativity in learning and living, and (3) Acquire the basic knowledge and skills needed to comprehend and express ideas through words, numbers and other symbols" (quoted in the 1983 Curriculum Guidelines

Computer Studies: Intermediate and Senior Divisions, p. 6). The second point is that, particularly at the time the statement was made, very little was known about the effects of using computers in the "more significant way".

The present study was proposed and designed to attempt to address this gap in our research knowledge by examining some of the questions implicit in the "Computers in Education" Memorandum. We wished to find out what happened when microcomputers were introduced into elementary classrooms with the intention of being used as vehicles for "extensions of original thought". In general, we wanted to observe the effects of this enterprise as it influenced teachers, children, and the curriculum. By examining a few "computer-enriched" situations in the early part of this decade, we hoped to be able to provide insights which would be of use to policy makers shortly thereafter, and to the majority of practitioners in the latter part of the eighties.

From the beginning, we felt that it was important for the study to have four general characteristics. The first of these was classroom realism: we wanted the classrooms we observed to be as representative as possible of Ontario elementary school classrooms. There were a number of implications of this decision. It was important to have a wide range of classroom situations for observation. In our selection of classrooms for participation in the study, we attempted to include settings which could be classified as: rural, urban (inner-city, suburban); primary, junior, intermediate; teacher experienced in use of technology, teacher inexperienced in use of technology; children with previous computer experience, children without prior computer experience; special education (learning disabilities, behavioral difficulties); high-structure methodology, low-structure methodology; and computer laboratory, computer in the classroom. In addition, in an attempt to simulate the situation which is likely to hold in most educational jurisdictions by the middle years of this decade, the co-operating teachers were not given specialized training or support in the use of the software they were to take to their classrooms.

The second characteristic was longitudinality. It was felt that the real impact of this technology would not necessarily reveal itself in a month or a term. We also wished to guard against excessive influence from a novelty effect. Accordingly, the study was designed for and was implemented over a period of two years. This feature alone came close to making the study unique at the time it was planned.

The third characteristic was that of software availability. A decision was made to use only software which both could be seen as a tool for creativity and which was available "off the shelf". Because of the relatively slow development pace of some of the software materials for art and music, the study's main emphasis focused on the classroom use of the computer language "Logo" and on the "Bank Street Writer" word processing package.

The fourth characteristic which we aimed for was accessibility of results. It was our desire to produce a document which was the result of rigorous analysis within the parameters of the methodological frameworks employed, but which would speak not only to our colleagues in educational research, but also to classroom practitioners, educational administrators, and members of the public at large.

Although the findings in this report were drawn from a computer environment, many have broader implications. The sections on students' confidence and self-esteem, student-student interaction, and the differential effect on male and female students, offer insights into the psychological and social needs of children and classroom life in general. The importance of the teacher in shaping how and what students learn (which is brought into focus in several of the sections) and the discussions on teacher-student interaction and on the role of the teacher are also relevant to any learning situation that attempts to promote creative expression. Some of the issues raised in the sections on the impact of innovation on teachers who are ready to accept change, and the impact of these teachers on the rest of the school, are also not unique to the computer.

The findings in the remaining sections are much more specifically tied to the computer or the software that was being used; but even there, issues of a more general nature are being raised. For example, chapters 18 and 19 raise some fundamental questions that relate to measurement and evaluation; and the insights gained from watching children interact with different, potentially creative, software, offer new perspectives on how children learn and on the tremendous untapped potential that children have for learning.

One person who knew of that untapped potential in children was Seymour Papert, whose vision brought about the development of Logo, the first computer language that enabled the computer to become a powerful ally to everyone, not only to those highly adept in mathematics or science. In his book Mindstorms (Papert 1980), he dreamt of the computer as becoming a medium that would assist children in taking greater charge of their own learning. The findings in this study confirm that dreams can sometimes become reality, for Logo has indeed given many children a powerful medium in which to explore, to experiment, and to reflect upon their own thinking. The most significant part of Papert's vision of the child as a new kind of learner, however, and one which tends to be ignored quite often, is the importance he gives to the cultural context and the adult role in guiding and assisting children as they live, learn, and explore. As he states:

> But 'teaching without curriculum' does not mean spontaneous, free-form classrooms or simply 'leaving the child alone'. It means supporting children as they build their own intellectual structures with materials drawn from the surrounding culture. (Mindstorms, p. 31)

Our study explores in considerable detail what these supporting structures might be and what happens when they are not given.

Part One: Research Design

1. SETTINGS
2. METHODOLOGY

1. SETTINGS

The study was carried out at thirteen sites during the first year and five of these sites continued to be studied more intensively during the second year. The grade levels studied were Kindergarten to Grade 8 inclusive - except for Grade 4. There were two split-grade classrooms in the study during the first year, and one split-grade classroom during the second year, making it possible to study some of the students over a two-year period under the direction of the same teacher. In total, there were 393 students who were in the study for one year and 40 students who were in the study for two years. Most students during the first year of the study had similar exposure (or lack of exposure) to computers. During the second year of the study, however, three of the classes consisted of a mixture of students who were new to the study and students who had been in the study the previous year.

The participating teachers had from five to twenty years of teaching experience, with the majority having taught about ten years. All teachers except one had had some previous experience with computers. Their experience varied from involvement in a two-day workshop to extensive regular use with a variety of computer languages. Six of the teachers had used computers in the classroom for short periods before this study (of these, five had used Logo). Six of the thirteen teachers approached the research team directly, asking to be part of the study. The remaining seven were approached by either a principal or superintendent about participating in the project. The teachers varied in their preferred teaching style from a discovery approach to a structured approach.

During the first year of the study, six of the settings used the facilities of a computer laboratory that had one available printer; five of these (Kindergarten, Grade 1, Grade 2, Grade 5 and Grade 8) were within one school and the sixth one (Grade 8) used a computer laboratory outside the school. Of those that had computers in their classrooms, one (Grade 1) had the use of three computers (all different models; only one supplied by the project) and one printer; and six (Grade 3, Grade 5, Grade 6/7, Grade 8, junior/intermediate learning disability, and an emotional adjustment class) had the use of one computer and one printer in the classroom. Two settings, (Grade 5 and Grade 6/7) received a second computer after the first three months, and during the second year they received two more computers and another printer. During the second year therefore, the Grade 5/6 (previously Grade 5) class had four computers (all one model) and two printers, and the Grade 7 class (previously Grade 6/7) had four computers (two different models) and two printers - a fifth computer (another model) was added later. The other two settings during the second year had two computers

(Grade 3) and three computers (Grade 1; two supplied by the project). Tables 1 and 2 provide a summary of initial characteristics of the students, the classroom, and the teacher for each site. Detailed descriptions of the school, the classroom, and the teacher for each site can be found in Appendix B.

Sites are identified by numbers and letters. The same number in year one and year two means that the site involved the same teacher and school, but that the students, the composition of the classroom, or the grade level were different for the two years. The letter "a" is given to all sites in the study during the first year. Any data reported under "a" does not differentiate between students who left the study after the first year and those who continued in the study for a second year. (Such distinction was made during the initial phase of the data analysis; however, it was decided to use this degree of detail only in the body of the text whenever necessary.) The letters "b" and "ab" refer to sites during the second year: "b" refers to that group of students who were new to the study at a given site and "ab" refers to the group of students who were also in the study (and who had the same teacher) the previous year. Since there were three sites (site 6, site 8 and site 9) during the second year that had both first and second year students in the classroom, these sites are the ones that are referred to in terms of "b" and "ab". Thus, references to site 6b and site 6ab, for example, do not imply two distinct physical entities or sites. Sometimes the notation "site 6 (b, ab)", for example, is used in the text. Such a notation usually implies that the emphasis is on the whole class, school, or on the teacher rather than on the two sub-groups of students.

The teachers in this study received minimal technical and curriculum support from the research team since one of the objectives of this study was to examine how teachers utilized a computer, a Logo system, and a word processor under "normal" educational conditions.

Table 1

Initial Site Characteristics: Students

	1st. Year Sites													2nd Year Sites				
Site Number	1a	2a	3a	4a	5a	6a	7a	8a	9a	10a	11a	12a	13a	2b	5b	6b ab	8b ab	9b ab
Characteristic																		
Grade	K	1	1	2	3	5	5	6/7	7/8	8	8	J	J	1	3	5/6	7	8
Number of Children in Class	24	27	21	22	22	27	32	26	32	17	32	5	4	24	23	30	32	33
Number of Boys in Class	4	10	12	9	12	15	16	11	15	6	16	5	4	17	11	18	17	16
Number of Girls in Class	20	17	9	13	10	12	16	15	17	11	16	0	0	7	12	12	15	17
Ability Range	A+	A	A-	A	A-	A	A	A+	A	A+	A+	-	-	-	A	A	A	A
Number of Children with Problems	1	0	6	3	0	0	0	0	1	0	0	5	4	4	0	1	4	0
% of Children who have used a Computer	83	44	90	95	18	74	94	-	-	-	-	60	75	92	4	100	100	100
Number of Children with a Computer at Home	1	0	0	3	2	5	2	4	1	2	0	0	1	0	1	8	11	8
% of Children who would like a Computer in the Classroom	92	96	92	99	73	81	84	-	-	-	-	5	2	87	96	-	-	-
% of Children who would like to learn more about Computers	-	-	-	-	-	-	-	100	97	100	94	-	100	-	-	93	100	97
% of Children who have used a Computer at School	-	-	-	-	-	-	-	100	97	12	94	-	75	-	-	67	88	85
% of Children who have read articles on Computers	-	-	-	-	-	-	-	58	56	35	75	-	4	-	-	57	84	70
% of Parents who have encouraged their Children to use Computers	-	-	-	-	-	-	-	50	50	70	78	-	50	-	-	13	75	75
Number of Computers in the Classroom	L	3	L	L	1	1 *2	L	1 *2	1	L	L	1	1	4	2	4	4	2

A+ Above Average
A Average
A- Below Average

L Computer Laboratory
* Number from Jan. to June

Table 2

Initial Site Characteristics: Teachers

	1st. Year Sites													2nd. Year Sites				
Site Number	1a	2a	3a	4a	5a	6a	7a	8a	9a	10a	11a	12a	13a	2b	5b	6b ab	8b ab	9b ab
Characteristics																		
Grade	K	1	1	2	3	5	5	6/7	7/8	8	8	J	J	1	3	5/6	7	8
Sex	F	F	F	F	F	F	M	M	M	M	M	M	F	F	F	F	M	M
Teaching Style	I	D	DI	SD	S	D	SD	D	SD	SD	I	S	D	D	S	D	D	SD
Have you taken a computer course?	N	Y	Y	Y	N	N	N	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y
Have you taken a LOGO course?	Y	Y	N	Y	Y	Y	N	Y	Y	Y	N	N	Y	Y	Y	Y	Y	Y
Have you had a computer in your classroom before?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	N	Y	Y	Y	Y	Y
Do you have a computer at home?	N	Y	N	N	N	N	N	N	N	N	N	N	N	Y	-	N	N	N
Have you been a consultant or resource person?	N	Y	N	N	Y	Y	Y	Y	Y	Y	-	Y	N	Y	Y	Y	Y	Y
How do you feel about teaching math?	-	VG	-	C	VG	C	NC	VG	VG	G	VG	-	NC	VG	VG	G	VG	VG
What grades have you taught in the past?	K, 1	K-4	1-2	K-6	1-13	1-8	6-12	3-13	K-8	4-8	3-12	SLD	Sp. Ed.	K-4	1-13	1-8	3-13	K-8

D	Discovery method	VG	Very Good
S	Structured method	G	Good
I	Integrated lesson plan	C	Comfortable
		NC	Not Comfortable

Table 3

Number of Site Observations of Students Working at the Computers

	1st. Year Sites													2nd. Year Sites				
Site Number	1a	2a	3a	4a	5a	6a	7a	8a	9a	10a	11a	12a	13a	2b	5b	6b -ab	8b -ab	9b -ab
Number of Observations	5	6	2	4	7	13	4	12	11	14	7	10	5	10	11	20	20	5

2. METHODOLOGY

If one had to summarize the design of this project in one sentence, then the following would be a reasonable first approximation: it is a multi-site, multi-method, and longitudinal investigation of microcomputer innovations in the classroom. The meaning of the term multi-site should be clear from reading the previous section. Longitudinal refers to the two-year duration of the project, a relative rarity in educational research, yet virtually essential when one wishes to address substantial educational issues. Many of the remaining paragraphs of this section will attempt to clarify the nature of the third characteristic: 'multi-method'. Before embarking on this task, the last feature of the opening sentence must be emphasized. This study was concerned with real classrooms. We have often found ourselves describing the study as involving "real classrooms, real teachers, and real kids". No attempt was made to use sophisticated sampling procedures; rather, the aim was to provide a representative picture. In retrospect, it seems fairly clear that the study has one definite positive bias - positive in the sense of teacher abilities and attitudes. The teachers were experienced, competent, extremely hard working, and genuinely interested in trying to incorporate microcomputers into their classrooms.

One source of information on personal backgrounds, reactions, and attitudes about computers was a set of questionnaires administered to teachers at the beginning of the study and to primary- and junior/intermediate-level students at the beginning and end of each year. (Primary-level students were interviewed.) The regular classroom observations always contained important discussions with the teacher, details of which were regularly recorded in site visitation logbooks. Meetings were scheduled every six weeks when all teachers participating in the study could meet to discuss the project with each other and with the research team. Detailed records were kept of these meetings. Students were also asked to react to and evaluate their experiences with the computers at various stages throughout the year and at the end of each year. In addition, students were given a Logo quiz on turtle geometry at the end of each year. (The same questions were given in both years.) The quiz for primary-grade students consisted of two parts. Both were administered individually to each student but one required responses to be recorded on paper and one required responses at the computer. The quiz for junior- and intermediate-level students required responses on paper and was administered to the whole class with the researcher in attendance to clarify questions. Students were asked to save their on-going activities at the computer either on paper or on a floppy disk. For certain periods during the year, junior- and intermediate-level students were also asked, before leaving the computer, to record on a pre-designed questionnaire (Items D.1 and D.2 in Appendix C) that was placed by the computer, certain details of and reactions to the activities they had just done on the computer. Many teachers asked their students to keep a computer journal which also became a rich source of data. Finally, the research team attempted to remain constantly sensitive to "on the spot" reactions. For example, in one of the classes students began to verbalize their concerns about the Logo quiz. The researcher in charge immediately asked students to record their reactions on paper and returned with unexpected "treasures".

Since one of the primary foci of the study was to report on how teachers and students coped with and adapted to the introduction and creative use of microcomputers in a "normal" school environment, each site became a case study. The data collected for this purpose were extensively open-ended and descriptive in nature. The guidelines and procedures for gathering such on-going data underwent several major revisions during the first three-month period, and further adjustments and adaptations were made during the second year. At the outset, each teacher and researcher received a description of the research project and the set of seven questions that the study was to address. These questions were:

1) How does a creative software program such as Logo enhance the teaching/learning environment to meet the objectives outlined in The Formative Years (the Ontario Ministry of Education's 1975 statement on the objectives of elementary education)?

2) What areas of the school program are best supported by the creative use of the computer in the classroom? For example, areas such as mathematics skills, artistic designs, logic, problem solving, and creative writing will be examined.

3) What changes, if any, are suggested in curriculum policy, given widespread use of creative computing software?

4) What specific skills, identified in The Formative Years, are more easily mastered by using a creative software program such as Logo?

5) What effects does a creative software program such as Logo have upon:

    a) classroom environment;
    b) teacher - student interaction; and
    c) the student - student interaction?

6) What effects, if any, might there be on present programs and practices in teacher education?

7) What unanticipated effects occur, if any?

The teachers and researchers were then asked to report anything that might be relevant to any of these seven questions in a logbook. Such an instruction proved to be too vague and teachers asked for more direction in carrying out their observations.

In response to this request, a questionnaire was constructed which divided the original seven questions into a total of 52 sub-questions. This questionnaire then became the basis for interviews in mid-November. It was then found that the original order of the questions did not reflect the teachers' priorities in making observations. Teachers would inevitably respond about the social aspects that they had noticed in the classroom, then about specific content or skills that affected the students, and only after they had reported on those immediate concerns were they ready to think about broader issues. In order to accommodate these "natural" priorities of teachers, the questionnaire was reorganized and administered in December, again in mid-March, and at the end of the first year. It was administered only once - in mid-year during the second year of the study. Since it was very difficult to administer such a lengthy questionnaire to many of the teachers during school-time, it was decided to remain flexible and allow teachers their preferred style of responding to it: some of the teachers filled out the questionnaire at their leisure and others preferred to be interviewed during lunch-hour, a spare period, or after school. Interviews were either recorded directly on paper or taped and subsequently transcribed.

It became evident rather quickly that the 52-item questionnaire (Item B in Appendix C) did not offer a convenient framework for recording on-the-spot events. Hence, another 16-item questionnaire (Item C in Appendix C) was constructed which was used by both teachers and researchers to record their on-going observations.

In order to record the developments and activities at each site chronologically, two documents were prepared for each site: Document B which used the categories of the 52-item questionnaire and Document C which used the categories of the 16-item questionnaire. Document C was merely a chronological compilation of on-going observations made by teachers and researchers that were recorded on individual 16-item questionnaires. Document B, however, contained the direct responses by teachers to the 52-item questionnaires and all the content (except questions 2 and 3) of Document C which was appropriately apportioned to one or more of the 52-categories: all in chronological order. (The transfer was made electronically with a word processor.) An additional "document" was compiled that arranged all the data recorded in Document B and Questions 2 and 3 of Document C, cross-sectionally. This "document" consisted of 54 manila file folders, each representing one of the 52 questions of Document B and Questions 2 and 3 of Document C. Each folder, therefore, contained all relevant data under each heading collected from all the sites. This "document" became the main reference for analyzing this source of data and for combining it with other available data, such as the results of the pre- and post- questionnaires, the Logo quizzes, student activity sheets, all the computer output, and computer journals collected from students. It was extremely beneficial to come to grips with this mass of diverse data by writing three-months and one-year interim draft reports.

No matter how easy or how complex the process of recording observations was, most teachers still found it difficult to record on-going observations. Being part of this study already demanded that the teachers learn about computers and Logo and how to utilize them in the classroom. The record keeping seemed to be an additional, "non-essential" burden. The amount and detail of observations recorded directly by the teachers varied greatly. The researcher's visits, therefore, became a crucial part of the data gathering process. Even during a 15-minute conversation a teacher could sometimes relate a wide range of activities and observations to a researcher who then recorded them in the appropriate document. Conversations that occurred during meetings or over the telephone were recorded similarly. The researchers also recorded their own observations of the school, the teacher, the students in the class, and of students working at the computer. Initially, an attempt was made to capture the dialogue of students at the computer with the use of audio-tapes. This approach was discontinued since it was found, when listening to the tapes, that it was difficult to tell who was speaking; nor could one understand the references without knowing about the activity the students were engaged in. It also was hard to differentiate between students at the computer and others in the classroom. Several video-tapes of students working at the computers were taken by the researchers with a portable video-camera. This resulted in some very good and some very bad footage because of technical problems and of the difficulty of getting around desks, computers, and students. More extensive practice in the use of the camera and the techniques of filming, before going into the classrooms, would have been very useful.

At the beginning of the study, an attempt was made to visit each site every two weeks and later, every three or four weeks. Initially, visits were "unannounced" but researchers often found students not in the classroom or not working at the computers (or in the computer-room). It was, nonetheless, often possible to speak to the teacher during such "unsuccessful" visits. Since every effort was made not to interfere with the regular classroom or school routine, and yet it was desirable to have first hand observations of students working at the computers, it became important to arrange for a suitable time or date ahead of time, especially for the locations that involved extensive travelling time. Because the focus of the research was to obtain a balanced view of classroom life and of students working at the computers, visits were staggered to include different days of the week and different parts of the day (mornings and afternoons). Except for the classes that used a computer room and those that were on a fixed 40-minute school time-table, observations in the classrooms usually extended over an entire morning or afternoon and on rare occassions over a whole day. In order to accommodate these different factors and situations, the number of visits per site varied considerably (Table 3) and the three researchers responsible for site visits had to remain extremely flexible; a tremendous imposition on the two researchers who, officially, were employed only half-time. The minimum number of direct observations of students at the computer during the first year was two and the maximum number was twenty, with an average of approximately eight observations; during the second year, the minimum number of direct observations was five and the maximum was twenty, with an average of approximately thirteen.

Researchers found they had a very sensitive role to play between that of a participant or advisor, and that of an observer. Both teachers and students often looked to the researchers to give them direction and advice. This was not the mandate of the research, since the primary concern was with normal classrooms (i.e., without a regular visiting resource person). At times, the researchers held back but at other times, in order to reduce the frustration level of the teacher, the necessary help was given. A similar stand was taken with students, but there were moments when temptation was too great and the researchers found themselves involved in the students' excitement and activity. Rather than rigidly adhering to objectivity and neutrality, the researchers decided to be scrupulous in recording their own input and actions as well as those of the teachers and students.

Researchers found that with time, their powers of observation became "dulled" and events became "normalized". Notes taken during a site visit therefore became less detailed with time. Teachers also experienced the same tendency toward habituation. Visits that were accompanied by other research team members or visitors brought new life to the researcher in charge since it heightened new awareness and introspection. During the second year, researchers were assigned different sites in order to bring a new approach and fresh perspective to each setting. This also served to validate or re-examine data gathered the previous year.

This research project did not set out initially to test certain hypotheses, but rather to find insights and to generate possible hypotheses. It was therefore important to remain alert and on the lookout for "interesting" bits of data. For example, a single comment by a teacher or student or an "interesting" response to a particular question started a serious search for additional pieces of a potential puzzle. This could only be achieved through intensive discussions among research team members and a thorough familiarity with the mass of data collected up to that point. The research team members remained in touch with events and developments in all sites through many casual discussions and weekly "project" meetings. If it was found that certain data was not reliable because of ambiguities in the questions given, or that insufficient data was available to test certain preliminary hypotheses that were generated from the collected data, the duration of the study made it possible to refine old items or to incorporate new ones in the questionnaires during the second year, or to return to the classroom for a quick interview or discussion with both students or teachers.

In dealing with a study as diffuse as this one was at the outset, it became extremely important for the research team members to examine their own bias, especially as it related to recording on-going observations and to understanding the contextual importance of the observations. The temptation to give personal meaning and interpretations, even to numerical data, was often quite great. Although bias can never be completely eliminated, every effort was made to examine a hypothesis or issue from many different points of view, to test its validity across the different grade levels, and to document findings from as many different sources of data as possible. Because of the breadth of the study, it was possible to validate the findings "internally," with one exception: the differential impact on male and female students. It was therefore decided to support the findings on this topic with those by other researchers. The strong time pressures in producing this report, coupled with interesting "last minute" developments that extended site visits right up to the end of the school year, made it impossible to do so for any of the other findings.

Three members of the research team had constant access to an APPLE II+ and a GUTENBERG word processing system. The latter was chosen, since at the start of the study it was the only word processor available for a microcomputer that made it possible to transfer information electronically between two files. The extensive use of microcomputers for word processing and data organization gave the research team independence and flexibility that was very important to the smooth functioning of the project and the speed with which data could be recorded and documents updated.

The research team made it clear to teachers from the outset that the study was attempting to document difficulties as well as successes. Teachers, however, were very reluctant to share their "failures". It was therefore extremely important to create a feeling of trust and caring among all participants. Just as many students in the study needed to be given a non-judgemental environment before they were willing to engage in exploring the unknown, so did the teachers. They needed to feel "safe" before they were willing to share their difficulties and failures with others. Sometimes, "true" feelings and difficulties did not come out until the end of the first year or during the second year - and seldom during visits in the classroom. Informal meetings therefore became very important. Throughout the study, individual teachers and research team members made a number of presentations at workshops and conferences. The teachers were free to attend these sessions and to react to them. Teachers were also given an opportunity to read the draft reports that had been written. However, since there was some concern that this might significantly influence teachers' behaviour in the second year, the question was discussed with the teachers: their consensus was to wait until the end of the study before they would read about any of the findings.

At the end of the first year of the study, it was found that other researchers and practitioners in the field were beginning to observe similar "macro" findings about Logo: for example, the positive effect on students' confidence, heightened peer-interaction, and the strong need for teacher support with Logo; findings that were being documented in this study. Also, at the end of the first year, several teachers independently expressed a feeling that the "ideal" number of computers for a classroom would be four. It was, therefore, decided to extend the focus of the research during the second year to include classrooms with more than one or two computers, to increase the frequency of site visits, and to attend to greater detail when observing students at the computers. Thus, three of the sites received two computers, one received four, and another five.

The greater concentration of computers in the classrooms and the need to make more frequent site visits made it impossible to continue the investigation without reducing the number of sites. It was, therefore, decided to reduce the number from thirteen to five. Three of the sites were chosen on the basis that they would represent classes consisting of a mix of new students and of students who had been in the study the previous year. Two others were chosen because they involved teachers in the same grade placement for the second year.

Enough exciting insights were gained from the special education settings at the end of the first year that it was recommended to the Ministry of Education that more intensive research in this area be pursued - research which could not be carried out within the parameters of our study. The decision to discontinue with the computer laboratory settings was a difficult one. However, the fact that the laboratory settings were not "typical" - in the sense of one being in a Kindergarten to Grade 13 school and the other at a university - greatly influenced the final choice.

This research report incorporates a large number of direct statements made by teachers and students. Unless a specific reference was used to make a unique statement, every effort was made to choose statements that were representative of other teachers or students, or that conveyed the typical variety in the responses. The same was true for computer printouts of student work. In reading the report, it is important to keep in mind that the findings are based on the experiences of thirteen teachers and a total of 433 elementary school students. Approximately 4000 graphics items (pictures or procedures on paper or on floppy disks) and 1000 items of text (produced on a word processor or with Logo) were collected. All were carefully examined and the examples of students' computer output used in this report were chosen from the total pool to illustrate common features, to show the range of 'typical' approaches, and to bring out novel approaches to an activity.

Part Two: Impact on the School Environment and Classroom Organization

3. DEMANDS OF INNOVATION ON THE TEACHERS
4. IMPACT ON OTHER MEMBERS OF THE SCHOOL
5. SPECIAL EDUCATION AND ITS EXTENSIONS
6. IMPACT ON CLASSROOM ORGANIZATION

PREAMBLE

One finding that is brought into focus throughout this report is that the teaching/learning environment greatly shapes the kind and amount of learning that takes place within it. This applies not only to students but also to teachers, especially when teachers have to deal with a new technology and new instructional modes. Part II, therefore, brings together the impact that this research had on teachers as innovators, on the school or the community, and the classroom adjustments that needed to be made in order to accommodate the computers. Chapter 3 offers some insight into the broader issues of innovation that the teachers who participated in this study had to confront and/or deal with. Chapter 4 describes the overall impact that our research had on the various members of the schools that were not directly involved in the study. Chapter 5 offers some sensitive insights into the two special education settings that were studied and the bridges that were created between "normal" and "special education" classes within the schools and beyond. Chapter 6 shifts the emphasis from the larger environment to the classrooms being studied. It describes the physical and scheduling modifications that were made in order to accommodate computers in the classroom routine.

3. DEMANDS OF INNOVATION ON TEACHERS

Innovators are always in a precarious position. The temptation to become a missionary or to work in isolation - "doing one's own thing" - is very strong. Innovators, in the early stages of change, often experience loneliness, alienation, distrust, fear, and suspicion. The teachers in this study experienced all of these emotions to varying degrees. Since they were usually the first teachers in their school to use computers and since they received almost no guidance from the research team, there was little opportunity to explore and discuss this new technology with others. The school visits by the researchers and the monthly meetings of project participants thus became an essential link that helped teachers to cope and persevere. The need for positive feedback and the desire to share common concerns, problems, and thoughts with others was very strong. Teachers also expressed a need to observe first-hand what some of their colleagues were doing. Several teachers arranged visits among themselves.

Innovations of any kind usually require a certain amount of "unlearning" as well as the learning of new skills and concepts and of exploring new ways to utilize them. Without exception, the teachers in this study found these new demands time consuming and difficult to achieve, especially since they were still responsible for meeting all of their regular curricular and extra-curricular activities.

Several of the teachers became involved in this study because they were looking for a new challenge and dimension to their teaching. As one teacher reported:

> I became interested in computers because I needed some excitement for myself. I felt that after teaching the same thing the same way for so many years, I wanted to explore new ways of teaching. (Feb. 11/83)

However, even the teachers who were very eager to participate did not fully realize the large personal cost involved, in both time and mental energy, in dealing with this kind of innovation. Enthusiasm and dedication, desirable in the teaching of any subject, became essential for overcoming the many difficulties, especially after the initial excitement gave way to the reality and demands of daily existence. Four months into the study one junior-level teacher reported:

> Knowing a little about computers is a dangerous thing. The more I learn, the more I

> realize how little I know. I am beginning to find this very intimidating. (Jan. 10/83)

Despite such a feeling, this teacher and others continued to explore the use of computers in ways that put children more in charge of their own learning. One teacher, however, found the obstacles too great and stopped using Logo after three months. He reported:

> I have discontinued Logo because I couldn't justify the time spent on Logo. The children lost their enthusiasm for Logo and I may have been to blame for that because I had no enthusiasm for it myself. (March/83)

Throughout the first year, several teachers remarked that the lack of current recognition of their own and their students' computer activities, coupled with the uncertainty about continued access to computers in their classroom beyond the end of the present study, made it very tempting to ask "what for?" The added uncertainty about the software or hardware with which they might have to deal at a later date also caused some teachers to pause and think. One teacher commented:

> Personal costs in this area should be no more or less than in other areas of upgrading! However, if I take a computer course, only to find that the language that I have learned cannot be used in another school or area, I would be very upset. (Dec.15/82)

All of the teachers expressed a need for support at both the curricular and technical level. Receiving hands-on time on the computer was extremely important to them. Some of the teachers took the classroom computer home in the evenings and on weekends so that they could learn the programming features and explore suitable challenges and ideas for use in the classroom. The teachers in the "computer-room" sites could not do so because the computers were used for adult classes in the evenings and on weekends, consequently, they felt greatly handicapped in what they could do. All teachers expressed a need for a consultant close at hand - especially in relation to hardware and programming problems - and they all concurred with what one teacher had to say:

> It is essential to have time on the computer with other people around to ask questions and to discuss things with. In-service from more knowledgeable people than myself. Also opportunities to share with someone else who is using the same computer and the same software to discuss ideas, problems and how to use it. (Jan. 31/83)

All teachers experienced periods of impatience. They felt that they were not developing their programming skills quickly enough, especially when they found that their students were moving forward rapidly. Logo itself, because it is so easy to produce "something" very quickly, tended to create unreasonable expectations about the time required to master the language. One primary-level teacher wrote:

> I spent at least six hours trying to become acquainted with Logo, but I still can't do ARCRIGHT, PETAL or FLOWER. It is fortunate that I have primary grade since they won't be to this stage for a long while, hopefully. (Nov. 8/82)

ARCRIGHT, PETAL or FLOWER are procedures that make rather sophisticated use of arcs. Even to contemplate doing such a design within six hours after opening a manual for the first time would be out of the question in any other computer language.

In addition to the demands of coming to terms with a new technology and exploring ways of utilizing this technology in exciting ways, many teachers were also faced with additional new situations, typical of those facing many teachers today. Two teachers, during their second year of this study, had to deal with changes in their teaching responsibilities within the school setting. One teacher was transferred from a single grade class to a split-grade setting that included an age group of students she had not taught for many years. Another teacher was assigned the responsibility of teaching language arts to all intermediate-level students in the school (which he had never done before), as well as that of teaching in a different grade setting. These changes placed very strong immediate demands on the teachers with respect to additional learning, exploration, and preparation time, which were in direct competition with the demands of exploring how to use the computer technology and Logo in these new settings.

Additional demands on the teachers' time and energy came from other teachers - inside and outside the school - who were curious or wanted to learn about computers or Logo. Such demands also came from consultants or administrators who wanted to learn or make policy decisions about computer applications in education. In their desire to share their own enthusiasm and knowledge with other teachers - and to take advantage of some exciting opportunities that presented themselves - the teachers in the study gave workshops to teachers and students within and beyond their school and on professional development days. They also served on board committees that prepared new guidelines or manuals for computer studies and/or Logo, and gave presentations at conferences and to classes at Faculties of Education. All but one of the teachers were enrolled in an additional qualification course in computing (Computers in the Classroom, Part I or Part II). As one teacher commented:

> The computer is a time sink. The more time I put in the more it runs out. The job isn't finished. I don't see it as finishing. I do find that we are going to have to learn to manage our time very effectively. I do find that the drains put on by other people have to be managed. (Dec. 15/83)

None of the teachers were unaffected by these external or self-imposed demands and in a few cases the stress became evident. Some teachers were able to take realistic stock of their own energies and began to refuse more and more requests from people (other than the research team) to visit their classroom and to reduce the number of workshops they were willing to give or committees they were willing to serve on. One of the teachers who had to contend with a particularly large number of such pressures developed severe medical problems by the end of the second year of the study, although a clear cause and effect relationship is impossible to document.

The demands of coping with something new and overcoming initial obstacles, especially when teachers received minimal assistance, were quite great. In the words of one teacher:

> Presenting a teacher with the program (Logo) and the manual and nothing else was like a nightmare! (May 15/83)

This was the most extreme response - but one which was shared in varying degrees by others - to the challenge of being creative with a new technology and computer language, with only minimal support or training, while carrying out the full demands of the regular school program. Despite this difficulty, all teachers in the study attempted to live up to the challenge: there were no "failures", either among teachers or students. Some teachers and students who didn't explore as deeply as others showed us the natural limitations to human energy and the consequences of structural restrictions (for example, school time-tables, curriculum, lack of support, and so on). Others who were able to delve more deeply into the possibilities of the new technology gave us insights into what is possible under some of the existing educational structures, and what might be possible if existing structures (both mental and physical) were modified. All of these experiences and findings have contributed to a deeper and broader understanding of how this new technology might be utilized in exciting ways.

4. IMPACT ON OTHER MEMBERS OF THE SCHOOL

THE PRINCIPALS

Although there were eighteen classroom-settings in this study, five of these were in one school that used a computer resource laboratory, and five others involved the same teachers in the same schools for two years; thus the number of school principals involved in this study was only nine. All nine principals were supportive of the research being carried out in their school, and all enjoyed the opportunity to be among the "more progressive" schools. There were differences, however, in the degree of personal involvement with respect to their own learning about computers, their observing of the students "in action", the active support they gave to the teachers in this study, and the leadership they took in promoting the general use of computers in their school. It was important that principals were able to identify a personally meaningful goal before committing themselves, their staff, and their students to the necessary outlays of time and money. These goals ranged from looking at computers as a means of meeting immediate administrative needs to looking at computers as an exciting new educational adventure for themselves, their students, and their teachers.

Two of the principals had attended a Logo workshop before our study began and were most enthusiastic to see their teachers get involved. One, gave a teacher who participated in this study time off in order to do some initial thinking and planning about utilizing the computer in her classroom. Another principal attended a Logo workshop to help him better understand some of the issues that were sure to arise. He was eager to extend his school's activities with computers, making some of his teachers uncomfortable with the pressure to get more involved with computers. He saw microcomputers as an opportunity for teacher development and for stimulating teachers who had become rather stagnant. Another principal, together with two of his teachers who were not participating in our study, took an in-service course on computers offered by his board. Even while he was still attending his own course, he and the other teachers began to give in-service sessions after school to the other teachers in the school. Two principals, although they did not use computers themselves, strongly supported the entire staff of their school to take advantage of the computer resource room at their board's teachers' centre. Two principals showed an interest in what was going on but gave only minimal support to the teachers involved in the study and more or less left it up to the teachers in their school to come to terms with this technology in their own way: however, they did support using Professional Activity Days for in-house workshops on computers. One principal stayed very much in the background and didn't take a personal interest in computers until parents of the class in the study realized that their children would not have a computer the following year.

This general overview seems typical of the "normal" range of reactions to innovation: however, there were several computer-specific issues that principals were very concerned about. The first, was trying to make sense of the tremendous range of available hardware and software. Principals were looking for guidance at a higher level in order to await a more co-ordinated policy across the school board. In the second place, the traditional school program already had to meet many worthwhile educational goals and computers were not an integral part of the recognized curriculum - they were still "on the outside" and considered a frill. There was no assurance that energy invested in support of this study could be used productively after the study ended. Third, schools are currently operating under very tight budget constraints and there was still uncertainty about using scarce resources for computers. The advantages of having one computer in the school were not evident. Fourth, there was a concern over equitable distribution of resources and support among teachers as well as students. Some of the principals felt uncomfortable giving special support to teachers involved in this study when they already were in a "privileged" position. Other principals gave teachers in our study more support if they believed that such support benefitted other students in the school. Finally, there was some uncertainty about the many fund-raising events already going on in schools. Three of the principals, one from a rural school, one from a mixed rural/suburban school, and one from a suburban school, did initiate a fund-raising drive. They did so primarily in response to the increased interest among teachers in their school to work with computers.

For principals, one immediate application of computers was for the administrative use of a word processor and a data bank and file system. One school was already using a computer in the office when this study began, another principal began to use the computer quite extensively for word processing, and another took a typing course in anticipation of a similar use. Two principals who were less committed to the use of computers in their school became more enthusiastic when they began to explore the potential of this technology to assist them in their administrative tasks.

Without any doubt, the teachers in our study who had the active support of their principals felt more secure in trying out new ideas. The principal was important for setting the tone and enthusiasm in the school, which gradually captured the curiosity and eventual committment of other teachers in the school. Leadership, in terms of igniting enthusiasm and in drawing out the expertise among teachers seemed crucial in the increased acceptance of computers in the schools. By the end of the study, all schools had from one to four computers, and several were making plans to buy additional computers for the next year. In several instances, where principals or teachers had not thought beyond the computer hardware, problems developed. Very few schools bought a printer - an essential for any visible record of work with computers. This is especially important for young students and imperative for word processing applications. One school bought a printer but did not realize that it did not have a graphics capability; hence, no pictures could be printed on it. More serious was the fact that the allocation of money raised for computers often failed to take into account the need for software, disks, and paper. Some teachers who were willing to work with computers were "stuck" with the hardware and no appropriate software. In some instances, unless the students provided some games or software, computers could not be utilized in the classroom.

OTHER TEACHERS

As with the principals, the usual range of reactions to innovation was noted among the other teachers at the various schools. A few teachers were genuinely curious and eager to learn about Logo from the outset. In two schools, a small number of teachers actually took lessons on Logo from students involved in this study. A more common reaction, however, was one of great reservation. In most schools, teachers felt ill-prepared for this new technology and the limited experience some had had with "the" school computer created more frustration than anticipation. The disparity in access to computers created some initial jealousy towards teachers in our study because they were seen as "privileged" and as getting all the attention. This eased somewhat as teachers in the study gave "in-house" workshops for teachers, and every teacher made some effort to give other students in the school access to "their" computer. Some teachers gave other students access during spare periods or before and after school; others set up periods where students in our study could teach others. One teacher helped others in the regular classroom when they had the school's rotating computer. The most ambitious undertaking was by one teacher who used his own free periods plus two that were given to him by his principal to teach all the students in the school the rudiments of computer literacy and a bit of Logo. He did this throughout the entire first year of the study. All the teachers in that school allowed their students to participate in this program; however, they did not take advantage of the opportunity to further their own knowledge about computers or Logo - they saw it as an opportunity to relax in the staff room. This teacher reported that:

> The result was that students knew and teachers didn't. The teachers would then shut down the use of the computer. They would say it's too disturbing, too disruptive to my lesson and a variety of reasons. (Dec. 15/83)

The teacher who experienced the greatest resistance summarized her experience:

> When I brought the computer to school I was really excited and I went into the teachers' room. I talked but no one was really listening and I got the feeling "Why doesn't she shut up and go away someplace". I still kept talking about it. The principal finally asked me to give a presentation at a staff meeting. I asked people if they wanted to come and see the children working on it. Well nobody came near the classroom; not even the principal at first. The principal eventually came, especially when there were visitors to the school but he never asked questions or stayed very long. It wasn't until the end of the year when parents realised that their children would not have a computer the next year that some interest was generated. They initiated a fund-raising drive. Now the teachers have to become a little bit

> interested because they have to decide what to do with this money. (May 19/83)

Such general reservation by teachers eased somewhat in most of the schools by the end of the first year. An increasing number of teachers began to take a variety of computer workshops or courses and to visit the experimental classrooms. Although the teachers' interests in computers gradually increased, many of the teachers applied their new knowledge chiefly to running drill and practice exercises. Others focused on teaching BASIC because that was still considered "the" language to learn and it was readily available on any computer. Seven teachers - five in one school - who became interested in computers but who were frustrated by the limited access to computers in their school, brought their own computers to school. This created some tension among the staff; and it also resulted in a great variety of models being used within one school with no compatibility or co-ordination among them. In addition, it supported personal preferences for computers based on familiarity rather than on educational evaluation. This strongly influenced subsequent discussion on how funds that had been raised for computers should be allocated. One teacher reported that:

> Fund-raising has been great. The question now becomes how best to spend the money. One of the advantages is that we have the money. The disadvantage is that if ten people who know nothing about computers are making the decisions we get what those ten people decide whether it is appropriate or not. (Dec. 15/8

Teachers who were "holding back" gave a variety of reasons. First, there was no clear policy with respect to the use of computers. Second, computers were not a recognized part of the curriculum. Third, making sense of existing hardware and software was a nightmare. Fourth, there was no guaranteed continuity. Fifth, having a computer for short periods now and then was more trouble than pleasure. There were some teachers who resisted going near the experimental classrooms for the entire year, and a small number did so until the end of the second year. Teachers who were participating in this study reported that teachers who sustained a negative stand made the following comments:

> I don't see any advantage in using word processing.
>
> Logo doesn't appeal to me. It's too much work.
>
> I don't think we're ever going to be expected to do this in elementary schools. Logo is so simple.
>
> I've only ten years left in teaching. By the time computers are required, I'll be gone.
>
> I'm not good with machinery.
>
> Can I just come in and watch sometime? I'm so scared of these things.
>
> If you do it for me my class will use the computer. I just have too many things to do to learn about that too.

> I never realized how much the kids know. How do I keep up?
>
> What do we do with them [students] next year?
>
> He is messing up my math curriculum.
>
> It's only a toy ... it will pass.
>
> It takes too much time, it's not worth it.
>
> So ... it can do art.
>
> Let's quit playing with this micky mouse stuff and get back to learning.
>
> Well, I can't see the use.

One junior-level teacher involved in our study expressed concern that some of the resistance from male teachers in her school may have had a sex bias. She remarked that:

> In my school the four people most interested are women teachers all with over 15 years of teaching experience. Interesting! (May 15/83)

A co-operative venture did occur between a junior-level female teacher and one of the intermediate-level male teachers in our study. Also, one teacher from this study found herself in a sensitive position when she took it upon herself, with the support of her principal, to organize and give a computer workshop to the staff in her school. Some teachers felt that she was transgressing her divisional boundaries. Divisional prerogatives also came into play when one intermediate-level teacher was somewhat upset that a junior-level teacher, who was in this study, deprived him of the chance to introduce students to computers; he wanted to be the one to have that pleasure. In the school that had a computer resource room, the imposition of our study actually helped to bring about more co-operation and cohesion - but also some strained relationships - among the staff of the various divisions since they had to work together in setting up a schedule for the computer room that met everybody's needs.

One additional concern arose when one of the female teachers in the school became pregnant. Her principal advised her not to go near the monitor, hence her newly found enthusiasm was short-lived. She allowed her students to continue using the computer; however, since they were only Grade 2 students they could not direct their own learning for very long and gave up on Logo. They used the computer to play some of the educational games which they brought from home.

OTHER STUDENTS

The interest among other students in the schools who did not have access to computers was very high. All of the teachers in this study gave other students in their school some access to the computers in their classroom. One teacher started a computer club for a small number of students during lunch hour. Two teachers allowed students to come to their classroom during lunch-hours, after school, and sometimes before school. Teachers also gave other students or teachers access to their computers and particularly to their printer (since it often was the only one in the school) when their own class was not in the home-room. At the intermediate-level, students who came to the experimental classrooms for general subject lessons were, whenever possible, given access to the computers in the room. One of the teachers gave a general computer literacy course to all of the students in his school. Three teachers and students from six of the classrooms in this study gave Logo lessons to other students for short or more extended periods of time. Two teachers offered an "enrichment" course on Logo for students in their school.

The two teachers from the special education setting found that the computer in their classroom served as an exciting means of breaking down perceptions and barriers between their students and those of the rest of the school. The fact that their students were "experts" at computers turned a generally negative image of these students into a positive one. This was very significant, especially for students in the emotional adjustment class. Students in that class had been quite isolated from the rest of the school - no one wanted to associate with "those" children. The computer in their class was a strong enough "drawing card" that students ventured into their classroom, which allowed them to interact in a positive manner.

THE PARENTS

A somewhat unexpected effect was the interest of parents. During the entire two years of this study, only three parents expressed concern over the use of computers in their children's classroom. One parent was concerned over possible health hazards of any electronic device and two parents, one of them a teacher, were concerned that their children would become too distracted from their regular school work, and they forbade them to work on the computer. Most concerns were at the other end of the continuum - not enough access. Many parents of the students who were involved in this study were concerned that their children might not have a computer once they graduated from the experimental classrooms. Other parents whose children were not in the study were beginning to express concerns about equal access. Many parents initiated or assisted in fund-raising activities in order to purchase computers for their school. Parents of one rural school in the study were particularly active in this regard. In addition, many parents, primarily in response to their children's enthusiasm about their computer activities at school, bought computers for their homes. Although this occurred more in suburban homes, it was not restricted to them. In one rural school, 26% of Grade 3 students had a computer in their home at the end of this study, which was approximately the same as the percentage of junior-level students in a suburban school. However, more junior- and intermediate-level students in suburban homes had computers compared to those in the rural setting. Overall, at the beginning of the study 7% of the students had a computer at home; by the end of the first year this had doubled to 14%; and by the end of the second year it more than doubled again (Table 4).

The models of home computers reflected the diversity in the market - at least twelve different models were identified - and only 25% had the capability of running Logo. Some of the parents began to express concern over compatibility with the computers that children were using at school. Some teachers became regular consultants to parents who wanted advice on what to buy. Those children who had a compatible computer began to bring their games (educational or otherwise) to school and shared them with others whenever possible.

In response to their children's involvement with computers, a small number of parents became interested in learning about computers themselves and several parents took an evening course on programming with their children.

Table 4

Percentage of Students With Home Computers

	Fall '82	Spring '83	Fall '83	Spring 84
All Students in Study				
Total Number of Students	291	291	142	142
	Percentages			
Boys and Girls Combined	7	14	20	37
Boys	10	19	22	42
Girls	5	9	18	30
Primary Grades				
Boys and Girls Combined	5	5	2	23
Boys	6	6	4	32
Girls	4	4	0	10
Junior Grades				
Boys and Girls Combined	10	13	27	33
Boys	11	17	22	28
Girls	7	7	33	42
Intermediate Grades				
Boys and Girls Combined	7	18	31	48
Boys	11	26	39	58
Girls	3	12	23	39

5. SPECIAL EDUCATION AND ITS EXTENSIONS

There were two special education settings in this study: site 12a, a learning disability class; and site 13a, an emotional adjustment class. Site 12a was in the study for only the latter five months of the first year and site 13a was in the study for the entire first year. In addition, the junior-level students of site 6ab (Grade 6) had an exchange with students from a mentally handicapped school for one week, and the primary-level students of site 5b (Grade 3) acted as teachers to students from their school's intermediate special education class. Also, in one of the Grade 1 classes (site 2b), one student had cerebral palsy. Special accessing devices, at first a button and later a joystick attached to his wheelchair, and a simplified version of Logo (called Pickman) were acquired for him by the school from the Ontario's Crippled Children's Hospital. In Pickman, the turtle is controlled through the selection of one of several commands that are displayed on the screen in the form of bliss symbols. Pickman can be either large or small; only three functions - FD, BK and CIRCLE - are available. The student also had a disk with ten games on it which were intended to improve his co-ordination. While he could only manage two of these by the end of the year, he enjoyed playing these games and could be left unattended for short periods of time. He could not change from one game to another by himself but his aide was there to help him. He usually spent twenty minutes per day on the computer.

At the end of the first year of this study, all participating teachers were asked to reflect upon their experiences with computers in the classroom and to bring out highlights and problems. The teachers of the learning disability and emotional adjustment class summarized their own and their students' experiences with such honesty and feeling that they deserve to be shared in an unaltered form with a wider audience.

LEARNING DISABILITY CLASS

The following is a transcript of how the teacher from this class described the impact of the use of a computer on the students in her classroom:

> I only have seven children (two are at Grade 6 and the others are at the intermediate level) and they are all on individualized programs. It was, therefore, simple to schedule their time on the computer with little dislocation of the regular program. Children each have

three 40-minute periods per week and there are a few free periods that can be used by anyone who wished. Some children are working through their recesses and their lunch hours; some are staying after school. It is in constant use throughout the week. The machine is never shut off. It's really wonderful to see that.

I don't know how much you know about SLD kids but many of mine have not been in a special education class before and their learning experiences have been very negative. They're bright to very bright kids who just can't read or write as well as the others and some of them are five or six years behind in these areas when they come to me. You can imagine the frustration they've gone through. Their general knowledge and their interests in current events is quite phenomenal. However, when it comes to applying these things in the classroom, to reading and to getting these things down on paper, the mechanics of it are very difficult for them. They don't know how so they just want to shove it aside. As a teacher you're therefore constantly looking for learning modalities that are going to attract them and take advantage of the skills that they do have. The computer has done that. It's been marvelous.

One girl who has difficulties in all areas, especially in mathematics, wouldn't even want to go near a book. We are watching the TVO program "Bits and Bytes" as a group in class. With the material came a program disk that has some games and multiplication bingo on it and she has just worked on the multiplications. It's just amazing. She is still using a multiplication guide but not so much anymore. When she goes to the computer she wants to do math and that just wasn't happening before. Also, never before have we touched on geometry because these children had not mastered their basic arithmetic skills. I am very ignorant in the math field and my knowledge of angles, drawing figures and other things was very limited and I learned a lot through turtle geometry with the kids. They were discovering angles almost immediately. They were very proud of that. One of the boys has just finished designing the emblem of a local shopping centre [see Figure 5.1]. He says it is so easy now. This is a boy who is going to be in Grade 8 next year, who is reading at a mid-Grade 2 level, and who has just finally mastered division with a two-digit divisor. He still needs concrete aids, yet he sits down at the computer and he can add numbers in his head, makes very good estimates, and is able to make rather sophisticated designs. He is constantly talking about it at his home. He has finally gotten some direction as to the kind of career he wants to go into - a real problem for a lot of learning disabled children. There are two boys in my class that are looking into that now for post-secondary work.

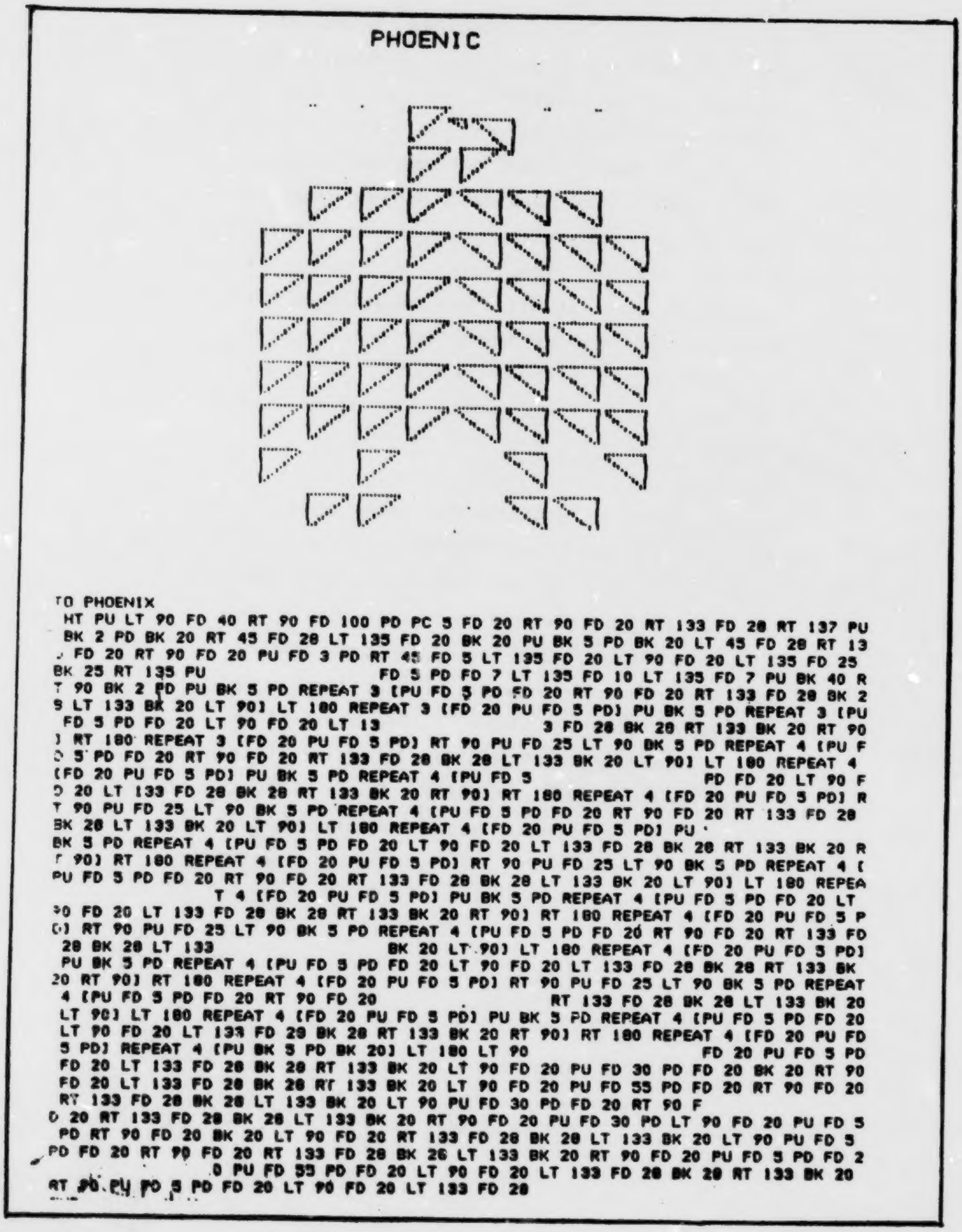
What we are doing with the computer right now is having the kids act as instructors. They are teaching Grades 1 through 5. Our school was able to purchase one computer; but one computer for 350 children doesn't go too far so two of these, Grades 1 and 2, were unable to schedule any time at all on the computer. The teachers of these classes came to us and asked if we could take their students in pairs. Two out of the three 40-minute periods are now instructional periods and they are marvelous. The kids make fantastic teachers. They are so patient. At first I was worried that the kids might lose interest because they knew all this stuff. This was very important for them. Some came to me and said: "Now I know why you like being a teacher; it's nice to know everything about something". As long as they keep thinking I know everything we're OK. The teaching is good for them because they need a lot of repetition. Most of the students' abilities to retain information are very poor. The computer has helped them with that. In their spelling they have much longer personal vocabularies, simply because they want to know words about the computer and use them with different programming terms. Not one in the class will spell any of these words wrong. Before, just to increase that list was really quite something. They never wanted to correct work before. It was a difficult thing for them to do especially in creative writing. You can't begin to imagine how difficult that is for some of these kids. All these ideas they have (and some of them are extremely creative) but they just can't get them down on paper or if they can, it is so painful that they would just as well not do it. Once they have done it; well, the thought that they might have to correct it is just too much. With the computer, however, they go back and correct their procedures even if they are phenomenally long. Some of them actually find it's fun to go back and try to find the errors. It's like a game or a challenge. There has been a carry-over to their writing. They aren't as reluctant to go back and correct their stories. Our printer was accidentally dropped one day when one of the children got it out of the locked closet (for safety reasons the computer was always locked away on weekends). Because of this we have not been able to develop our writing program. A printer is absolutely essential for that.

Concentration is a big factor in dealing with these kids. Many of them cannot attend to a task when they first come to my class. To get them to work for an entire period of forty minutes is a near impossibility but the kids are on the computer for forty minutes and they don't want to leave it. At the beginning I was very concerned about this concentration factor and how they might be distracted by the computer in the room. I thought my God, we'll never get anything done. I decided to let it go the first week. If someone was working on the computer, anyone could go and see what was going on at any time, no matter what we were doing. That's all it took! Now, when somebody else is working at the computer they are concentrating. I asked my students whether they noticed anything other than improved spelling or math while working at the computer. They couldn't tell me. Then I asked them "How long do you work at the computer?" They replied "a 40-minute period". When I asked them "How long do you normally work on a math sheet or whatever without getting out of your seat or asking a question?" Then it hit them! Working on the computer and staying there has carried over very definitely with every child. They are working independently more than they have before.

I asked my students to write down how they felt or what they thought about working with computers; how the computer helped them or if they disliked something about the computers. One said he really enjoyed working on the computer because it put him in a different world. I think if they can find an area of learning that is a little easier it is a different world for them. It is a more pleasurable world and successful world for them.

Figure 5.1

'PHOENIC' a Drawing Designed in Logo By a Student From a Learning Disability Class



PHOENIC

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TO PHOENIX
 HT PU LT 90 FD 40 RT 90 FD 100 PD PC 5 FD 20 RT 90 FD 20 RT 133 FD 28 RT 137 PU
 BK 2 PD BK 20 RT 45 FD 28 LT 135 FD 20 BK 20 PU BK 5 PD BK 20 LT 45 FD 28 RT 13
 FD 20 RT 90 FD 20 PU FD 3 PD RT 45 FD 5 LT 135 FD 20 LT 90 FD 20 LT 135 FD 25
BK 25 RT 135 PU                    FD 5 PD FD 7 LT 135 FD 10 LT 135 FD 7 PU BK 40 R
T 90 BK 2 PD PU BK 5 PD REPEAT 3 [PU FD 5 PD FD 20 RT 90 FD 20 RT 133 FD 28 BK 2
8 LT 133 BK 20 LT 90] LT 180 REPEAT 3 [FD 20 PU FD 5 PD] PU BK 5 PD REPEAT 3 [PU
 FD 5 PD FD 20 LT 90 FD 20 LT 13                     3 FD 28 BK 28 RT 133 BK 20 RT 90
] RT 180 REPEAT 3 [FD 20 PU FD 5 PD] RT 90 PU FD 25 LT 90 BK 5 PD REPEAT 4 [PU F
D 5 PD FD 20 RT 90 FD 20 RT 133 FD 28 BK 28 LT 133 BK 20 LT 90] LT 180 REPEAT 4
[FD 20 PU FD 5 PD] PU BK 5 PD REPEAT 4 [PU FD 5                   PD FD 20 LT 90 F
D 20 LT 133 FD 28 BK 28 RT 133 BK 20 RT 90] RT 180 REPEAT 4 [FD 20 PU FD 5 PD] R
T 90 PU FD 25 LT 90 BK 5 PD REPEAT 4 [PU FD 5 PD FD 20 RT 90 FD 20 RT 133 FD 28
BK 28 LT 133 BK 20 LT 90] LT 180 REPEAT 4 [FD 20 PU FD 5 PD] PU
BK 5 PD REPEAT 4 [PU FD 5 PD FD 20 LT 90 FD 20 LT 133 FD 28 BK 28 RT 133 BK 20 R
T 90] RT 180 REPEAT 4 [FD 20 PU FD 5 PD] RT 90 PU FD 25 LT 90 BK 5 PD REPEAT 4 [
PU FD 5 PD FD 20 RT 90 FD 20 RT 133 FD 28 BK 28 LT 133 BK 20 LT 90] LT 180 REPEA
               T 4 [FD 20 PU FD 5 PD] PU BK 5 PD REPEAT 4 [PU FD 5 PD FD 20 LT
90 FD 20 LT 133 FD 28 BK 28 RT 133 BK 20 RT 90] RT 180 REPEAT 4 [FD 20 PU FD 5 P
D] RT 90 PU FD 25 LT 90 BK 5 PD REPEAT 4 [PU FD 5 PD FD 20 RT 90 FD 20 RT 133 FD
 28 BK 28 LT 133                   BK 20 LT 90] LT 180 REPEAT 4 [FD 20 PU FD 5 PD]
 PU BK 5 PD REPEAT 4 [PU FD 5 PD FD 20 LT 90 FD 20 LT 133 FD 28 BK 28 RT 133 BK
20 RT 90] RT 180 REPEAT 4 [FD 20 PU FD 5 PD] RT 90 PU FD 25 LT 90 BK 5 PD REPEAT
 4 [PU FD 5 PD FD 20 RT 90 FD 20                     RT 133 FD 28 BK 28 LT 133 BK 20
 LT 90] LT 180 REPEAT 4 [FD 20 PU FD 5 PD] PU BK 5 PD REPEAT 4 [PU FD 5 PD FD 20
 LT 90 FD 20 LT 133 FD 28 BK 28 RT 133 BK 20 RT 90] RT 180 REPEAT 4 [FD 20 PU FD
 5 PD] REPEAT 4 [PU BK 5 PD BK 20] LT 180 LT 90                  FD 20 PU FD 5 PD
 FD 20 LT 133 FD 28 BK 28 RT 133 BK 20 LT 90 FD 20 PU FD 30 PD FD 20 BK 20 RT 90
 FD 20 LT 133 FD 28 BK 28 RT 133 BK 20 LT 90 FD 20 PU FD 55 PD FD 20 RT 90 FD 20
 RT 133 FD 28 BK 28 LT 133 BK 20 LT 90 PU FD 30 PD FD 20 RT 90 F
D 20 RT 133 FD 28 BK 28 LT 133 BK 20 RT 90 FD 20 PU FD 30 PD LT 90 FD 20 PU FD 5
 PD RT 90 FD 20 BK 20 LT 90 FD 20 RT 133 FD 28 BK 28 LT 133 BK 20 LT 90 PU FD 5
PD FD 20 RT 90 FD 20 RT 133 FD 28 BK 26 LT 133 BK 20 RT 90 FD 20 PU FD 5 PD FD 2
              0 PU FD 55 PD FD 20 LT 90 FD 20 LT 133 FD 28 BK 28 RT 133 BK 20
RT 90 PU FD 5 PD FD 20 LT 90 FD 20 LT 133 FD 28
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EMOTIONAL ADJUSTMENT CLASS

The emotional adjustment class consisted of five boys. The class had one computer and printer for one school year. The following are excerpts from a transcript of the presentation the teacher from this class made to the research team and to the other participating teachers at the end of the first year of the study:

> This year has been a brand new experience for me, not only as a teacher but as a person. I had seen movies and heard about children with problems such as my boys had but dealing with such children was new to me. I was frightened about it. Then came the call about the computers and I thought "I'm going to have a little arcade set up right in the middle of the school and all these tough punks who usually spend their time in an arcade will come to play on their little computer and they'll ignore me". That, to a great extent, was just me not understanding the capabilities of the students and of the computer. I think that the sharing that can happen with the computer takes a lot of time to cultivate and you can't just throw it in there and say OK, because we only have one computer in the class and five kids to work on it. I found with my boys, regardless of timetable difficulties, it had to begin with one person on the computer with myself. They had not gotten to the point where they would share things. Although my boys immensely enjoyed the things they were able to produce on the computer, when they were frustrated they couldn't ask it a question and they didn't have the ability to go back to the edit mode to find out what they had done. They couldn't ask a question and get a response.
>
> Machines didn't seem to fit into a humane environment for me but so many things didn't fit into the type of classroom that I was walking into. I began to question myself in that I had a large piece of equipment worth a lot of money and could probably be a super teaching aid but I didn't know enough about it

myself. I can't even read the instructions on how to operate a toaster. I would read the manual but I was never any further ahead and I couldn't figure out why there was a picture in the book and I didn't have it on the screen. This really put me back on a level with my students. We would sit at the computer together and experiment, and if they asked me a question I would have to say "Am I God? do I know? We got the computer at the same time; you tell me." It was really good that way. We established a relationship with each other that was very important.

Again back to the humane classroom: sometimes I'd get a little worried when all of a sudden I'd hear a wham and knew somebody's fist had landed on the keyboard. Really these computers are made well and they do take a lot of punishment. I think the big thing is that the computer doesn't have any tears and I think tears are really important because sometimes the computer elicited tears but it wasn't able to share in the problems the students were having. Although I think they will be a super teaching aid and I think they're great in the classroom and great for all kinds of people, I don't think I'm going to lose my job or any of us are ever going to be replaced because a computer can't hug a child or a computer can't cry with a child or listen to a child or share things.

Some of the things we went through: we all went through the Bank Street Writer Tutorial but there were a lot of little things for them to remember. I was just as happy for them just to stick with the Text Edit mode disk and they typed all their creative stories on it. They much preferred the keyboard to writing by hand. Dynatrack, I don't know who invented Dynatrack but I hate it. My guys would sit for two hours and play Dynatrack and they learned to set it slow enough and work the little thing around for hours. They would print out their score and they'd have this great score and soon they thought "I'm great!" I shouldn't say I hated it so much because if they wanted to take an hour when they were feeling bad, in a rotten mood or hadn't succeeded somewhere else they could put in Dynatrack and use it. The first thing they always wanted to show people when they came in was Dynatrack. Although it took up a lot of time which I thought was wasted that was my value and it was wrong at the time. I'm learning so much more about myself and the kinds of things that can help students. That is something they can be very successful at.

My students were very proud that they had something that nobody else in the school had. My boys are in a unique situation. The classroom, until this year, was in one end of the school and they were a part of the school but also not a part of the school because they were "that" class. No one else ever went in that class and I understand why. Sometimes the sounds that came out of that class were a little bit frightening. However, this year people wanted to come in. People wanted to see the computer. Grade 7 and 8 students came in and actively participated with my boys. My boys were proud that they could explain something to Grade 8 students. Everyone wanted a share in it. Just recently my boys have started working together at the computer.

So many incredible things have happened to me this year and to my students and, I guess, to us as a group. A lot of that is some sharing that we're able to do now and some caring. The main premise I have for my classroom is love. I think that it's something that a lot of people overlook in programming. Students need so much more love than they get at home or on the street or in an arcade or sitting in front of a computer. The computer has not taken away from it all and it has been a way to bring us together to

> talk about things and to care about each other and share the kinds of things we are doing. Now, at odd times, sometimes when things are going well, I notice four boys at the computer and no fists flying. No arguments and the four of them are working around the computer together. They have started to become much more sophisticated because there are other students in the school who come in often to use the computer and they see something that someone else has done and they want to know how to do it. They do it but they don't quite understand it; they work backwards and I don't think there is anything wrong with that either. They are into Basic now. They did my biorhythm chart the other day and that was kind of interesting. I had no idea that could be done. I don't know where they found out how to do it.
>
> I hope we never see every student hidden behind a computer. I think it's great to have a few in a classroom for the advantages it can give. However, I always want to see people in the classroom and people sharing things.

This teacher explored every possible avenue within his school board to find enough money to buy a computer for his class the following year.

MENTALLY HANDICAPPED STUDENTS

During the second year of the study, a teacher of a mentally handicapped class, and the teacher of site 6 (b, ab), met at a Computers in Education course. They shared their common philosophies and concerns and, as part of their course requirement, planned and documented an exchange between the Grade 6 students and the mentally handicapped students from a nearby school. Both groups of students hosted each other in their own school and learned about each other before they began to share their Logo experience. The exchange was a great success and both teachers and students expressed great pleasure at getting to know each other. The drawings presented in Figure 5.2 are a few samples of what the mentally handicapped students made after their second or third session with Logo. The students named their own picture but the teacher of site 6b recorded the comments below the picture.

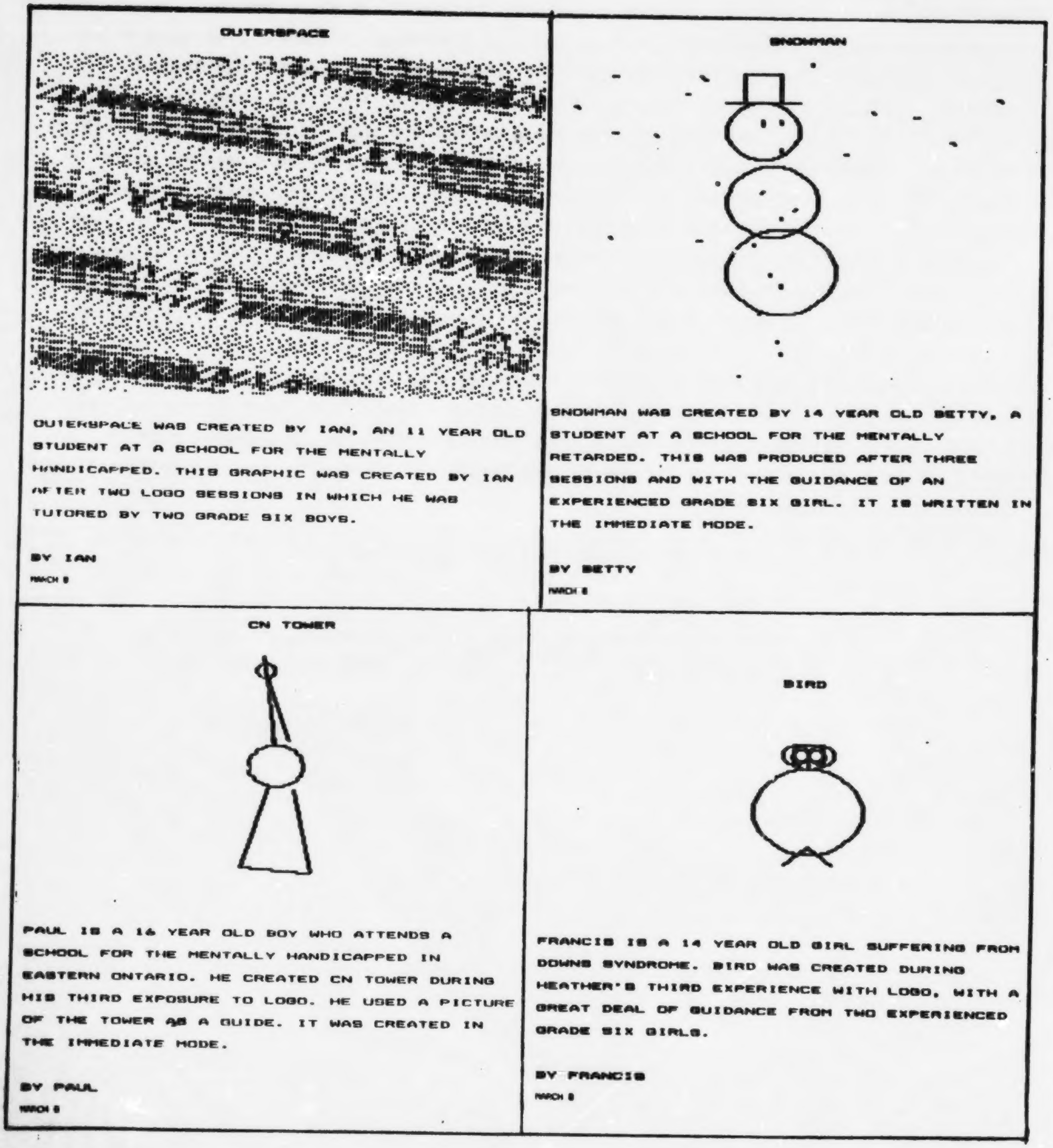
The teacher of site 5b (Grade 3), while discussing computers during a casual conversation with the senior special education teacher of her school, became concerned that other students in the school did not have access to computers. She therefore worked out a schedule with the special education teacher whereby her students could come to the Grade 3 class for four out of six afternoons per school cycle, for a 40-minute period at the computers. Eight Grade 3 students were given some basic instructions on "how to teach", stressing the importance of giving information when needed and then letting students explore on their own. The Grade 8 "special education" students agreed to being taught by the younger ones. The senior students worked with their young "teachers" for about four or five sessions after which they expressed a desire to experiment on their own. For their free explorations, some of them used the work cards on polygons that the teacher had made for her Grade 3 students. They began to change the procedures and enlarged on the ideas. They were exploring these ideas in the Direct Draw mode and called upon their "teachers" only when they needed help. Most of the senior students learned to save on disk and read back a picture from a disk. One or two of them could use the DUMPER print program which asked for text input. Obtaining printouts of their pictures was very important to the students. The Grade 3 teacher reported that the interaction between these senior and primary students was very good. Two of the senior students volunteered to be lunch room monitors in her classroom and often stayed with the students during the whole lunch period when they could not go outdoors.

The special education teacher saw the computer as a means for positive reinforcement for work completed and for good behaviour. It seemed to work since students were very eager to partake of this opportunity. For them it was something special "in the senior end of the school" since others did not have access to computers yet. The teacher gave the following summary of what it meant to her students:

> It has helped students to think abstractly, to solve problems on the computer. It has been socially beneficial and it has promoted co-operation with the primary "teachers". It has also given me time to work with fewer students on specific problems while four were engaged in another class at the computer. (May 2/84)

Figure 5.2

Examples of Pictures Drawn by Mentally Handicapped Students Using the Direct Draw Mode of Logo During an Exchange With a Grade 6 Class



OUTERSPACE

OUTERSPACE WAS CREATED BY IAN, AN 11 YEAR OLD STUDENT AT A SCHOOL FOR THE MENTALLY HANDICAPPED. THIS GRAPHIC WAS CREATED BY IAN AFTER TWO LOGO SESSIONS IN WHICH HE WAS TUTORED BY TWO GRADE SIX BOYS.

BY IAN

MARCH 8

SNOWMAN

SNOWMAN WAS CREATED BY 14 YEAR OLD BETTY, A STUDENT AT A SCHOOL FOR THE MENTALLY RETARDED. THIS WAS PRODUCED AFTER THREE SESSIONS AND WITH THE GUIDANCE OF AN EXPERIENCED GRADE SIX GIRL. IT IS WRITTEN IN THE IMMEDIATE MODE.

BY BETTY

MARCH 8

CN TOWER

PAUL IS A 16 YEAR OLD BOY WHO ATTENDS A SCHOOL FOR THE MENTALLY HANDICAPPED IN EASTERN ONTARIO. HE CREATED CN TOWER DURING HIS THIRD EXPOSURE TO LOGO. HE USED A PICTURE OF THE TOWER AS A GUIDE. IT WAS CREATED IN THE IMMEDIATE MODE.

BY PAUL

MARCH 8

BIRD

FRANCIS IS A 14 YEAR OLD GIRL SUFFERING FROM DOWNS SYNDROME. BIRD WAS CREATED DURING HEATHER'S THIRD EXPERIENCE WITH LOGO, WITH A GREAT DEAL OF GUIDANCE FROM TWO EXPERIENCED GRADE SIX GIRLS.

BY FRANCIS

MARCH 8

6. IMPACT ON CLASSROOM ORGANIZATION

PHYSICAL ARRANGEMENTS

Finding space for one computer and one printer in a regular classroom was not much of a problem, but finding a handy electric outlet was. Since it was desirable to place computers near electrical outlets, it was often necessary to rearrange other activity areas or even the whole classroom. Where this was not possible, extension cords became a safety hazard as students moved about. The problem became more serious as the number of computers in the classroom increased. One teacher strung a long extension cord up the wall and behind the ceiling tiles and then suspended it over the computers, which worked reasonably well. Another teacher carefully placed the computer away from the main traffic and in a carpeted area so that she could run the extension cord under the rug. The Bell & Howell EDUMOD version of the APPLE II+ computer came supplied with three electric sockets on the unit, which was of great benefit in keeping the cords for the monitor and printer close to the computer itself. Power bars were also used for this purpose but since desks weren't large enough to accommodate all the equipment, power bars often had to be placed on the floor. In a class with five computers, the mass of cords made the computer area look like "spaghetti alley", and the tangle of cords became a potential hazard to students as well as to computers. In addition, in one of the classrooms a janitor refused to clean around the area. He claimed that computers weren't a normal part of a classroom, hence it was not part of his contractual duties to clean the computers nor to lift anything to clean under them. Cleaning the computers themselves became a real concern since cleaning arrangements in classrooms did not take into account the vacuuming of chalk dust from floors and board ledges on a regular basis. One teacher, who took it upon himself to vacuum the keyboards, felt that computers should have dust covers overnight.

The scarcity of space, electrical outlets, extra chairs or desks, and even finding a grounded extension cord, became serious issues when more than one computer was placed in a regular classroom. In addition to the computers, space and equipment were needed for support activities, such as bulletin boards for displaying students' work and posting challenges, T.V. monitors for demonstrations and sharing sessions, and shelves or cabinets for storing activity cards, manuals, and other materials.

Accommodating additional equipment in a regular classroom that is not designed for that purpose led to the physical crowding of desks. This had rather interesting social ramifications that were raised by a junior-level teacher, who noted:

> Classrooms are small and room has to be found for computers. Traditionally-rowed desks take up far too much space, so teachers, implementing the use of the computer in a room, must rearrange the classroom furniture. This usually means having students sit closer together and students sitting together socialize more easily. Since students are naturally gregarious, this closer arrangement results in a higher noise level. This is a development a teacher may dislike or take advantage of in an effective classroom; some teachers may find this incredibly distracting. ... If the computers are to become an integral part of a room, they will be used continually. A lot of moving around, typing clatter, printer chatter, beeps, etc.. Children seem to adapt quite easily to this. Some teachers may not. My student teachers found the movement, noise and interaction noise intolerable at times. (May 15/83)

When there were only one or two computers in the classroom, the teachers found that it was preferable to place the computer(s) in a somewhat self-contained area so that students either on or off the computers had a better chance to focus on the activity they were engaged in (diagrams of the various settings are provided in Figure 6.1). They also found that enough space had to be made available around the computers so that, at times, the excitement of new discoveries could be shared by several students clustering around. One teacher used a bulletin stand to create a physical barrier between the computer and the rest of the class; others placed the computers in areas that were out of visual line of regular classroom activities. When students were asked, "Are there things you didn't like about having a computer in your classroom?" (Table 5), over half of the intermediate-level students were able to identify at least one problem, with noise level being the most commonly cited. Although not as frequent, both primary- and junior-level students were able to list a number of problem areas.

When using a computer-room, the physical layout was found to be of considerable importance. Teachers made the following recommendations:

1) Teachers should find it easy to circulate among the students, and the computers should be arranged in such a way that a lesson or demonstration is easily visible by all students from the computer. If this is not possible, enough space should be allowed for a general congregation for such purposes.
2) There should be room for additional "off-line" desks near the computer where students can work on other schoolwork while they await their turn at the computer.
3) The space needs to be arranged in such a way that one teacher can easily supervise activities on the computer as well as those at the desks.

The computer room brought out some unique problems that did not exist when computers were used in the regular classroom. Since a computer room usually serves a variety of students who differ greatly in size, accommodation seems to be made for the older student.

The primary grade students, therefore, had to deal with high tables and high chairs, all of which made it difficult for them to reach the keyboard of the computer and particularly to reach behind a computer for the ON/OFF buttons. In a regular classroom, the chances of having access to the appropriately sized furniture were much better. Also, one printer per computer room made it almost impossible to obtain copies of students' pictures or to get printouts of stories. Young students, especially, liked to have concrete evidence of their work and teachers sometimes spent many hours outside regular classroom time printing out the students' pictures. In addition, the physical process of booting up (i.e., turning on the computer and loading it with a program) all of the machines sometimes took as much as 15 minutes out of a 40 minute session. This, coupled with the time it took to move from and to the classroom and the fact that two or three students had to work at each computer, resulted in an actual contact-time with the computer, per student, of about ten minutes per period. Some of the classes were only able to schedule one session per six-day cycle, which gave each child very little hands-on time on the computer. If one considers that each child had to learn the mechanics of programming and meet the challenge of being creative on command within ten minutes, the experience became rather overwhelming to both students and teachers. Their accomplishments, therefore, are even more admirable.

Almost all of the teachers who made use of the computer room felt they would prefer one computer per student and to work with small numbers at any one time. The primary teachers in particular felt that, given a choice, they would prefer three to four computers in their classroom all day. As one of them pointed out:

> It is difficult to create a "Logo environment" when Logo is used in the computer room. It is quite a distance from our classroom and because of the physical organization it doesn't lend itself to a primary classroom atmosphere. It is difficult to draw students together in the computer room for a demonstration or lesson, and when we get back to the classroom there is no computer to demonstrate with. While occasional use of a computer room is certainly an advantage, the ideal situation would be to have four computers in the classroom. Logo activity would have more continuity, demonstrations would arise spontaneously, and integration of computer activities into classroom activities would happen naturally. (May 12/83)

Figure 6.1

Sketches of Floor Plans for Classrooms With Two and Four Computers and For the Two Computer Laboratory Settings

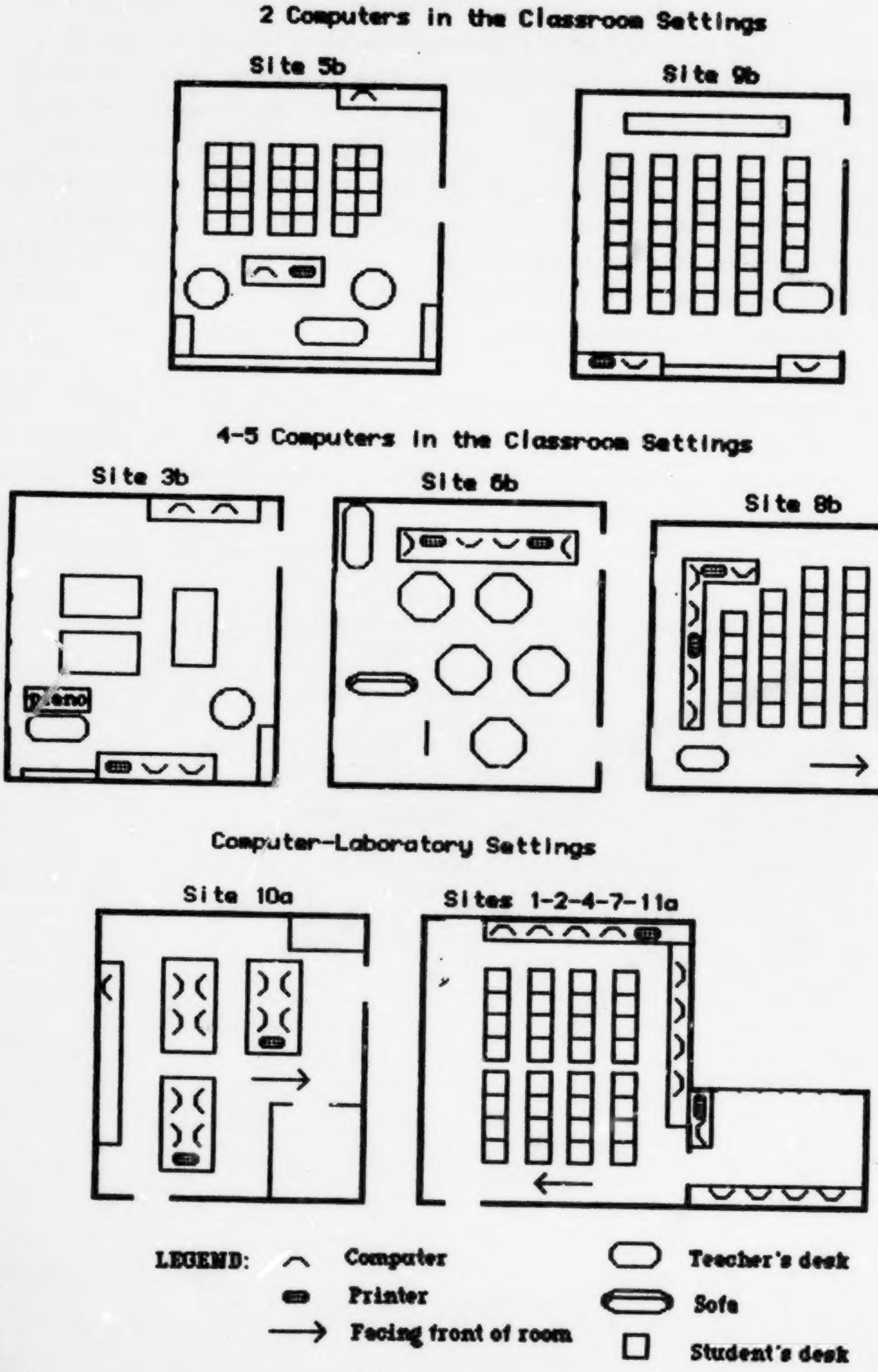

2 Computers in the Classroom Settings
Site 5b
Site 9b
4-5 Computers in the Classroom Settings
Site 3b
piano
Site 6b
Site 8b
Computer-Laboratory Settings
Site 10a
Sites 1-2-4-7-11a
LEGEND:
Computer
Printer
Facing front of room
Teacher's desk
Sofa
Student's desk

Table 5

Responses to "Are there things you didn't like about having a computer in your classroom?"

	Frequencies		
	Primary	Junior	Intermediate
Yes	13 (19%)	22 (41%)	62 (52%)
No	57 (81%)	30 (57%)	49 (42%)
No answer	0 (0%)	1 (2%)	7 (6%)
Total	70 (100%)	53 (100%)	118 (100%)
	Analysis of "Yes" Responses		
Conflict with regular class activities	1 (1%)	10 (19%)	17 (14%)
Noise level:keyboard, printer, beeps, talk, movement	0 (0%)	3 (5%)	22 (19%)
No help when needed; concern something might go wrong	6 (9%)	2 (4%)	1 (1%)
Difficulties with partners	1 (1%)	3 (5%)	7 (6%)
Conflict over computer access	1 (1%)	1 (2%)	7 (6%)
Miscellaneous reasons	4 (7%)	3 (6%)	8 (6%)
Total	13 (19%)	22 (41%)	62 (52%)

Table 6

Responses to "Are there things you didn't like about going to the computer room?"

	Frequencies		
	Primary	Junior	Intermediate
Yes	4 (11%)	6 (22%)	8 (21%)
No	33 (89%)	17 (53%)	13 (33%)
No answer	0 (0%)	4 (15%)	18 (46%)
Total	37 (100%)	27 (100%)	39 (100%)
	Analysis of "Yes" Responses:		
Conflict over computer access	1 (3%)	3 (11%)	5 (13%)
Noise level	1 (3%)	2 (7%)	0 (0%)
Difficulties with partners	0 (0%)	1 (4%)	0 (0%)
Miscellaneous reasons	2 (5%)	0 (0%)	3 (8%)
Total	4 (11%)	6 (22%)	8 (21%)

Also, carrying disks, manuals, and seat-work for those students who weren't working on the computer was rather awkward with very young students.

The Grade 1 and 2 students who used the computer room but who also had occasional access to one computer in their classroom or in a small withdrawal setting, were asked which they preferred. Out of a total of 37 students, 3 preferred the use of the computer in the classroom ("If you need help you get it" and "Quieter"): 30 of the 37 students preferred the computer room. Some of the reasons they gave were:

> Has more computers; more room; you can fit more people in.
>
> More fun; lots of people to talk to.
>
> Not so noisy; more peaceful.
>
> Teacher doesn't tell you what to do. Computers not so high.
>
> You can see more of the school.

When primary, junior, and intermediate students were asked if there were "things they didn't like about going to the computer room" (Table 6), only 18 out of 103 students had some mild complaints. Those pertaining to the use of the computer room (as distinct from the activity on the computer) were:

> Don't like to sit at the desk and wait.
>
> Don't like to go in line or wait until everyone is finished.
>
> Too noisy; too much hassling.
>
> Don't get enough time on the computer; sometimes don't get on at all.

One intermediate teacher was asked by one of the visiting guests whether he would trade his computer in the classroom for gaining access to a computer room. His reply was "no", although he would enjoy having access to a computer room at times.

Additional concerns that were raised about computers and their use dealt with:

1) Desks that were too high for the kids to be comfortable; they could use properly sized tables with enough room to place notebooks and books.
2) Lighting: glare off the computer screen from lights above it bothered many of the students. It was impossible to turn off the row of lights that were causing the problem without turning all the lights off.
3) The coloured screen was no good for word processing. It was entirely too hard on the eyes. (May 30/84)

The use of a robot turtle also required free floor space that was smooth and, preferably, uncarpeted. In one classroom, water damage had lifted some of the floor tiles just enough that the turtle could not navigate over them, and the turtle could not leave a trace when the floor area was not firm. Under these circumstances the use of the floor turtle became an exercise in frustration for the teacher and the students instead of a positive learning experience.

Interestingly, several teachers, regardless of the computer setting or grade level, spontaneously came up with an "ideal" number of computers as four. However, during the second year of the study, the two teachers who had four computers in their classrooms found it very difficult to remain indifferent to the noise level. On occasion, computers had to be shut down until some order could be established. Although students seemed to have a fairly high tolerance level for noise (only 3 students mentioned noise as a problem at the end of the first year of the study), 17 out of 32 students in the intermediate class that had four computers and a relatively small classroom complained about the noise level at the end of the study. The constant beep of one of the computers and the noise of the printers were found to be particularly annoying. Even when students weren't bothered by the noise, teachers found that any normal conversation had to be raised several decibels when the printer was in operation. One intermediate-level teacher wrote:

> We need an arrangement that accommodates the noise of printers, that deadens sound, that allows communication between students while the teacher may be effectively lecturing at the front of the room, that allows a student sitting near the computer area to see and hear effectively the remainder of the room. (Dec. 15/83)

During a period of rather hot weather, the crowding in one classroom also caused considerable discomfort to students, teacher, and the computers. The room was facing an inner courtyard which naturally created a pool of hot air. The additional heat generated by four computers and monitors added to the students' discomfort and caused the computers to behave rather erratically. The computers had to be shut off until the teacher helped matters somewhat by bringing a fan from his own home.

During the second year of the study however, those teachers who had four computers found it undesirable to "hide" eight or more students behind a barrier. As one intermediate level teacher noted:

> A problem is evident. I cannot see all stations while teaching and neither can the pupils see me. Voice level increases at these stations, not because the pupils are bad but because they enter a microworld within the class and for a few moments become so engrossed they hear nothing but their own eagerness to talk. Unfortunately their microworld affects ours. I'll need a solution soon. (Oct. 21/83)

He resolved it by bringing the computers into the classroom area so that he and the students had mutual visual contact. This way, a glance was often enough to remind students to "tone down" and students still remained somewhat in touch with what was going on in the regular classroom. The junior-level teacher who had screened off students the previous year when she had two computers also brought all four computers within open view of the whole classroom.

SCHEDULING

One of the strongest factors influencing how teachers scheduled the use of computers was the way in which they could justify to themselves, to other teachers, or to the parents of their students, the time required for Logo activities. This was of particular concern at the beginning when students had to learn the mechanics and skills of dealing with the hardware, the keyboard (typing skills), and the programming language. One of the teachers expressed this concern as follows:

> The demands of the curriculum don't at times, leave room for computer studies. This ever increasing time problem is going to be a must to deal with in the future. (Feb. 12/83)

It became very clear that before a computer could be utilized in an integrated and creative way, some basic skills had to be mastered. Just as it is necessary to master the skills of reading and writing, at least at a rudimentary level, before they can become tools for learning and creative expression, so it was necessary to acquire similar rudimentary skills with computers and Logo before they could become the basis for further learning.

The teachers who were able to integrate the computer into the daily routine of the classroom were willing to suspend, at the outset, some of the needs of the regular curriculum so that both they and their students could learn about Logo and about how computers could best serve their needs. A Grade 1 teacher described her rationale for time spent on Logo as follows:

> I have had difficulty getting ideas for integrating Logo into the curriculum guidelines: Reading - no, because two-thirds of the class can't read yet. Math - comes the closest, in that geometry is involved, although at this point the students are not aware of it. Environmental studies - this is the classroom subject that I am sacrificing for Logo as I feel strongly that reading and math should not be sacrificed but computers could be a very real part of these students' environment at this school. (Nov. 24/82)

A Grade 3 teacher who was teaching students of average to below average academic abilities felt considerable pressure to bring students up to "grade level". Three months into the study she still found that:

> It is difficult to cover the school curriculum and still give the students enough time on the computer. ... As yet I cannot see how to fit the computer into my classroom other than as an extra activity. But this is a plus. I cannot imagine what would happen if it were removed. (Nov. 10/83)

However, since her principal was very interested in knowing about the potential of Logo, he eventually "found" her a "free" 40-minute period per six-day cycle, and he also gave her the use of the school's other computer during that time. This enabled her to teach only four students at a time and to experiment in a small group setting. Within two months, she was able to integrate the computer activities into her regular program. She rationalized the time spent on the computer as follows:

> All the 5 minutes and 10 minutes wasted in one way and another throughout the day would add up to another unit of computer time. (Jan. 21/83)

Towards the end of the school year, the computer, which at the beginning was an extra to be worked on during recess and lunch-times, became an integral part of the classroom routine. She reported that:

> We timetable around "Logo" times. Each child now has his/her own timetable. I have found it is best to set out the work expected from my students during the whole week. (April 15/83)

During the second year of the study, this teacher integrated the computer activities from the beginning. She no longer had any difficulty justifying taking 20 minutes each day from the time allocated to language arts or mathematics. She already knew - it was no longer an act of faith - how computers could be integrated and how they would benefit the regular curriculum. The students expressed surprise that everyone would have equal access and that the computers were not merely treated as a special privilege for good behaviour or work.

One intermediate-level teacher could not reconcile the demands of the existing curriculum with the demands of the computer. He gave several lessons on Logo and attempted to give students access to the computer throughout the day. However, he found it unmanageable to let students work on the computer while other lessons were being held. He found it too time-consuming to repeat lessons for individuals and felt that only "A" students could be trusted to make up missed lessons without additional supervision. He therefore only gave students access to the computer during spare periods, periods of "seat work", and during lunch-time. Nonetheless, he was anxious that his students gain better access to the computer and he arranged to be available for assistance to them after school or in the evenings a few times. During the second year, with two computers, he was more comfortable giving students twenty minutes at the computer at the end of the first period in the morning throughout the year. Another junior-level teacher who was assigned one 40-minute period per week in a computer-room, after exploring Logo for two months, could not justify to himself the time spent in terms of the curriculum, especially since he saw Logo only in the context of mathematics and he did not teach this subject. He quit using Logo altogether, although he still continued to use the computerroom on occasion for word processing. It is interesting to note that the following year, this teacher, when he was no longer a participant in this study and after taking a Computers in the Classroom course, reported:

> I was hung up on the first introduction to Logo I had - math. That is Logo is a math

> tool. I now realize it is very versatile and has a multitude of uses in Language Arts, Visual Arts, etc.. (Feb. 8/84)

Other important factors that influenced teachers' scheduling of computer activities were the external structure that dictated how and where students were to be instructed, the preferred teaching style, and the educational philosophy of the teacher. External structures were imposed at the intermediate level by the existence of a rotary system and by scheduling demands of access to the computer resource room. These demanded a strict adherence to 40-minute periods and, in the case of the rotary system, also implied that students spent only part of their day in their home room.

Such structural constraints gave teachers fewer opportunities to create a flexible classroom routine and to integrate different subject matter with the Logo activities. The full impact of these structural parameters was felt by one of the teachers who taught a split Grade 6/7 class during the first year and a straight Grade 7 during the second year of the study. Although half of his class was on rotary the first year, he was able to integrate two computers into his classroom in a flexible and exciting manner. During the second year, even with four computers in the classroom, the pressures of the timetable and the demands of other teachers became rather strong. He wrote:

> December holidays gave me a chance to work on pupil records and to think about problems related to the class. Conclusions:
>
> 1) I have become tied to curriculum and intimidated by other teachers to work within their style. The result is that:
>
>   a) Rarely have I given a computer period for discussion due to the timetable.
>
>   b) I have denied adequate time for new learners on the computers, always relegating to noon hours and after school what is best accomplished at the time the problem occurred.
>
>   c) I have placed undue pressure on pupils to keep up with both activities and resulted in almost ignoring those pupils who, due to pressure, felt they could no longer use computers.
>
> 2) Pupils need regrouping and there are partnerships that are not working. I have not allowed time for this.
>
> 3) Pupils new to the class in September still need the personal help I gave all my pupils last year. Peer teachers work but many are stuck at a low plane of learning.
>
> 4) I am frustrated trying to live with different standards.

He resolved to take the following actions:

> 1) Pupils are to be regrouped after two weeks of observations and working with each personally.
>
> 2) I reaffirm to be me and teach and operate in my own style. This may cause internal conflicts in the division but I've decided not to be boxed.
>
> 3) One period per week will be set aside for discussion re learning, problems and lessons needed.
>
> 4) Each week the class will be broken into groups and together given class time to work out a challenge that will stretch the group into a new area of learning.
>
> 5) Log writing time is to be reinstated and read by the pupils to me to help both my understanding and theirs. (Jan.4/84)

He made several attempts to carry through the proposed plan of action, but the structural demands and the unwillingness of other teachers to engage in a more flexible program (i.e., less rigid adherence to the timetable) made it almost impossible. This teacher felt the structural impositions more than other teachers in similar situations because his preferred teaching style came in direct conflict with external demands.

Some teaching styles make it easier to adapt to computers than others. A teacher whose classroom was structured around activity centres merely added the computer as one of them. A teacher who had a structured classroom, either by choice or due to external conditions, tended to view the computer as another subject that needed to be scheduled into the time-table. Integrating the computer activities in a variety of subjects was more difficult in structured situations and the tendency to view the computer as a vehicle for teaching computer literacy or programming became quite strong. During one of the visits to a junior-level class that had managed to integrate the computer activities into the classroom life, one of the researchers made the following observation:

> I can see that a lot of what is developing in Mrs. Cook's classroom is possible because of the informal structure at work in the classroom. Children are communicating throughout the day to make the organization of computer time work by helping each other to catch up on any worked missed while they were on the computer. (March 10/83)

By the end of the first year, four sites (two primary, one junior, and one junior/intermediate) had integrated the computer into their daily program. In those classes, the computers were used throughout the whole day, even when other lessons were being conducted, although exceptions were made when the teacher felt that he/she was teaching a critical lesson (mathematics tended to be one of those). Students would usually sign up for a block of computer time at the beginning of the week and then rotate according to this schedule. Time blocks ranged from 15 to 60 minutes. One teacher who had used 20 minute blocks, found that to be insufficient time for the Bank Street Writer since she did not want to interrupt the students' train of thought. They also needed time to print out their stories. Students generally were assured a fixed number of time-blocks per cycle and additional ones were either assigned at random or on a first-come first-served basis. During the second year, a primary class that had two computers settled on two 40-minute blocks and one 20-minute block per six-day cycle for a total of 100 minutes per cycle. These blocks were scheduled during the morning; during the afternoon, computers were used on a more casual basis. Three periods per week were always used for the Bank Street Writer and students used their word processor for recording their diaries. Students in the junior-level and intermediate-level class that had four computers were assigned approximately 35 minutes on the computer every day. In order to accommodate up to eight students working at the computer at any one time, the junior-level teacher arranged her class into four groups and created a "floating" time schedule. A typical schedule for students while they were in her home room was as follows:

Time	Activities	Groups			
09:10-09:25	Reading Activities	1	2	3	$\underline{4}$
09:45-10:25	TV Ontario (varied topics)	1	2	$\underline{3}$	4
10:40-11:15	Music (another teacher)				
11:15-11:50	Math - no one at computer				
12:50-01:30	Social Environmental St.	1	$\underline{2}$	3	4
01:30-02:05	Finish up time.	$\underline{1}$	2	3	4
02:25-03:00	SQURT Journal: (Sometimes computer scheduling and sometimes not - depends on what is being done. If this were a computer demo period, no one group would be at the computer. (Note: SQURT - Student Quiet Reading Time)				

The group marked with the '_' would be working on the computer and the other groups would use the "Finish-up time" to catch up on activities and assignments missed during the day.

Teachers who had students working at computers throughout the day had to make major adjustments in time-tabling and classroom management. A Grade 3 teacher reported:

> Management of time is of vital importance so that each child has an equal amount of time at the computer, they must also not miss any of the teaching of other skills and concepts. Hence, my complete reorganization of timetable. Assignments are given, marked and recorded on a weekly rather than a daily basis. Each child is responsible for covering the weekly assignments by Friday. More checklists and tighter organization are needed for the teacher!! Thank goodness for parent volunteers!! (Dec. 15/83)

This teacher had one or two parent volunteers throughout the year and she believed that having "only" 23 students was an advantage. Schedules generally became more flexible towards the end of the year. Students could swap their time, and in one Grade 1 class students were allowed to stay as long as they wanted - in which case they tended to stay for 15 to 60 minutes. Very seldom did a child stay at the computer for longer periods. In the second year, this teacher chose to retain such an "open" schedule from the beginning of the year since it required a minimum of attention by both her and the students. However, this approach was abandoned by a relief teacher and the computer became accessible to students only after their "regular" work was done. The needs of meeting the demands of the "regular" curriculum not only required teachers to maintain closer management of students' work, but also placed demands on the students. Older students were held responsible for "staying in touch" and finding out about assignments and missed work. Most students coped quite well, although as the year progressed, more and more students at the intermediate level began to skip "computer time" because they needed to attend to demands of the regular curriculum or to special assignments, such as the science fair and the school play.

Increased use of the computer laboratory also highlighted concerns over co-ordinating access among all potential users. The intermediate class using the computer laboratory at the Faculty of Education at Queen's University had to be scheduled so that regular demands of the Faculty were not infringed upon. A suitable schedule was worked out between the teachers of the class and the university so that students came once a week from 11:00 a.m. to 2:00 p.m., making allowances for a thirty minute lunch break. (They were transported from and to school by school bus.) The computer experience was treated as an enrichment activity and was taught by a resource teacher, with the regular classroom teachers coming as observers. No attempt was made by the classroom teachers to connect the Logo activities to the regular curriculum. Originally, permission was obtained for eight sessions but because of the high level of interest, additional permission was obtained for eight more. No conflict seemed to exist over scheduling this type of an arrangement.

Such could not be said for the five classes that used a computer-resource room in their school. The school faced a unique problem in that it was a K - 13 school and the computer room had already been fully scheduled for high-school and adult classes. A great deal of co-operation was required before time could be freed for the elementary classes participating in the study. In this case, teachers also had to adjust to the computer room time schedule which was set in 40-minute blocks. The individual schedule that was eventually adopted by each teacher depended on the total number of free sessions for the elementary panel and on the teacher's degree of interest. The Kindergarten teacher, for example, did not use the computer room until each child had worked individually with Logo in the classroom. She was able to use the school's two "roving" computers for two hours each day for this purpose. Eventually, two classes chose to have one period per week, two classes had two periods per week, and the intermediate class chose to have one period each day. The teacher of the latter class chose to take part of his language arts period for computer purposes. Some of the time missed was made up during spare periods. At times, there were problems with conflicting schedules and the classes could only use half of the computer room (six machines) because the other half was in use. Some unique problems emerged from the use of a computer room:

1) Fitting as many as 33 students into a computerroom with 12 computers and making sure that each student has some access during the 40 minute period can be rather challenging.

2) The booting up of the computers with the required software took up a considerable portion of the class-time, especially when there was only one disk available for the purpose, or when small students did not have the skill of handling disks. When the time-block was only 20-40 minutes, this became an important concern.

3) Working in the computer room with very young students who did not know the rudiments of a computer language was extremely frustrating for both the teacher and the students. These students are very impatient and demand immediate attention and explanations. One primary teacher felt that the difficulty could be overcome if students could learn the rudimentary keyboard and programming skills in a small group setting - either in the classroom, or outside the classroom with a resource teacher.

Despite the problem of crowding, waiting for turns at the computer, and the high noise level, students recorded fewer "dislikes" about the use of the computer room than about the computers in the classroom (Tables 5 and 6). This was primarily due to the fact that students in the laboratory setting did not have to worry about other things that might have been going on in the classroom while they were on the computer. The whole class "missed" the same thing, or everybody, under the teacher's direction, made up the part of the regular curriculum that had been suspended during the time in the computer laboratory.

At the end of the first year, students were asked if they had enough time on the computer (Tables 7 and 8). Of the primary grade students, 83% indicated that they did, but when they were asked if they would have liked more time, 55% still said "yes". The junior-level students felt the greatest need for more additional time: 48% of those with two computers in the classroom and 67% of those who used the computer laboratory but quit after three months. Of the intermediate-level students who had a computer in the classroom, 29% would have liked more time on the computers. Surprisingly, there was only a 4% difference between the intermediate-level students who used the computer primarily during their spare time (site 9a), and those who had approximately sixty minutes in a six-day cycle (site 8a). Among the students who used a computer laboratory for either one 40-minute per day or for three hours per week, 20% recorded that they would have preferred more time on the computers.

Table 7

Responses to "Do you feel you had enough time on the computer?"

(By Students Using a Computer Laboratory)

	Frequencies		
	Primary	**Junior**	**Intermediate**
Yes	**31 (84%)**	**7 (26%)**	**28 (72%)**
No	**5 (13%)**	**18 (67%)**	**8 (20%)**
I don't know/no answer	**1 (3%)**	**2 (7%)**	**3 (8%)**
Total	**37 (100%)**	**27 (100%)**	**39 (100%)**

Table 8

Responses to "Do you feel you had enough time on the computer?"

(For Students Using a Computer in a Classroom)

	Frequencies		
	Primary	**Junior**	**Intermediate**
Yes	**39 (83%)**	**12 (48%)**	**36 (62%)**
No	**8 (17%)**	**12 (48%)**	**17 (29%)**
I don't know/No answer	**0 (0%)**	**1 (4%)**	**5 (9%)**
Total	**47 (100%)**	**25 (100%)**	**58 (100%)**

The most common arrangement of students at the computers was to assign pairs of students to every machine. The pairing strategies in most classes usually underwent several changes. At the outset, teachers tended to pair the students either randomly or on the basis of academic ability. Eventually, students were allowed to choose their own partners and to change whenever they could make suitable transfers. Working in pairs also seemed to be the arrangement preferred by students themselves, especially at the outset. Whenever they had a choice, the majority chose to work with someone else. This seemed to change to some degree as students progressed. A need to work independently for some periods before working with someone else again seemed to become more pronounced as students gained greater facility with the programming language and when they worked on the word processor. The junior-level students in the second year of the study, for example, expressed the strongest desire to work alone even though they had access to four computers in their classroom throughout the day. They were the one class that used the word processor quite extensively. These students were given several assignments which had to be done on the word processor and which had to be handed in within a fixed time frame. When such time pressures became strong, when there was too great a spread between the programming skills of the partners, or when the interests were too diverse, partners tended to split their assigned time on the computer or to change partnerships. New partnerships tended to be formed predominantly on the basis of shared interests or on an eagerness to learn from each other. On average, about half of these partnerships changed at least once. Changes tended to be more frequent in classes and among new students that had less direction or support from the teachers.

Some general rules and observations about partnerships emerged:

1) Contributions to a computer session were more equitable if:

   a) Students of similar ability worked together. If the spread in competency between the pair was too large, the more able student eventually tended to dominate the less able one.

   b) Students were generally willing to share and to cooperate. However, if one student was more extroverted than the other, he/she tended to dominate the activity on the computer.

2) A student who was a passive observer in one pairing situation often became the dominant individual in another pairing.

3) Almost all students liked to take turns typing. This was particularly pronounced in the very young grades. When not in charge of the keyboard, the very young students (Grades K to 2) tended to turn their chairs around, look at whatever else was going on in the room, or participate in the regular class activity until it was their turn. Discussions about the actual computer activity were generally of short duration.

4) Some students liked to hide behind their partner's abilities. Care had to be taken to encourage them to become more independent and confident in their explorations.

5) Groups of three students on the computers seemed to lead to a considerable degree of frustration since each student had to spend a great deal of time watching and/or received very little "hands on" time.

6) Conscious effort on the part of the teachers needed to be made to create and foster an atmosphere of co-operation and tolerance; this seemed to be particularly important for the success of mixed gender groupings.

Part Three: Social Dimensions and Their Impact

7. EFFECT ON TEACHER-STUDENT INTERACTION

8. EFFECT ON STUDENT-STUDENT INTERACTION

9. EFFECT ON STUDENTS' CONFIDENCE AND SELF-ESTEEM

10. DIFFERENTIAL EFFECT ON MALE AND FEMALE STUDENTS

PREAMBLE

Contrary to the commonly expressed fear that computers are dehumanizing, the way they were used in most of the classrooms studied brought into sharp focus social and individual issues. In Chapter 7, some of the difficulties and benefits that were encountered in re-examining and redefining the traditional student-teacher relationship are documented. The role of the student as a peer-teacher is also explored. Since many teachers extended their students' opportunities for social interaction inside and outside the classroom, and most students worked at computers in pairs, Chapter 8 describes the impact this had on students interacting with students. It also analyses the factors that came into play, especially those dealing with a student's social and individual needs, as pairs of students worked together over an extended period of time. Chapter 9 documents and analyses in considerable detail the impact that such a heightened interactive social environment, and the computer activities themselves, had on students' self-concept and confidence. Chapter 10 explores social and other dimensions operating within and outside the classroom that led to a differential impact between boys and girls, especially in one junior/intermediate class.

7. EFFECT ON TEACHER-STUDENT INTERACTION

At the outset, frustrations arose for both teachers and students. For example, a teacher of an intermediate class wrote in his notebook at the very beginning of the project:

> Some pupils are overbearing. Constant interruptions. Teaching today was a bust. I felt like I lived in the centre of a three-ring circus. I solved this problem by giving a structured lesson. (Sept. 29/82)

However, six weeks later he wrote:

> The children don't need me as much. They are developing great confidence with the machine. Machine failures are fewer and when they occur, the pupils are reacting as normal. (Nov. 9/82)

The degree of frustration was greater and longer for teachers who used a computer laboratory setting in which they had no assistance, had no ready teaching aids for students, and were restricted to twenty to forty minute periods once per week. A Kindergarten teacher reported:

> ... the first trip to the computer room was overwhelming. It took 15 minutes to boot all the computers since there was only one language disk. I found that I could spend no time with any one group. I will not go there again until there are more disks and some help with booting the machines. I have found this experience of no benefit to the children and too overwhelming for me. (Dec.12/82)

Before she used the computer laboratory again, this teacher chose to teach some of the rudimentary skills, such as letter and number recognition and programming skills to the children on the school's rotating computer in her own classroom. She also made arrangements to have student and parent volunteers assist her in the computer room. Several months later she was able to report:

> Two grade 8 students booted seven machines with Logo. Parent volunteer in today and day went much smoother. ... Still difficult to observe much when students are learning to boot machines. There is improvement. They can do it! (March 7/83)

One junior-level teacher who had access to the computer laboratory once a week, was too overwhelmed by the confusion and experience and stopped using Logo after three months. He found that:

> The major problem is how to answer 33 questions in 40 minutes and give help to the class at the time that they need it, which is at the computer. I have tried discussing this after in the classroom, but it is 7 days before they get to try the results and often they forget and start at square zero again. (March 11/83)

It was not until he had the opportunity to take a "Computers in Education" course from a highly competent instructor who taught him how to "teach" Logo as "a guide by the side, not a sage on the stage", and who encouraged the attitude "what if you tried this", that he was able to turn Logo into a positive experience for his students.

It became obvious rather quickly that if learning was to take place in an interactive and creative manner, teachers needed a "sense" of direction which went beyond knowing Logo as a computer language. One primary teacher who had one computer in the classroom reported that:

> I am trying to tie in the computer activities with the general themes being explored in the classroom, both in Logo and Bank Street Writer. My emphasis is on student-student interaction (sharing of ideas, communicating), thinking skills, and creativity. I spend a lot of time thinking about how best to accomplish this. Activities must be challenging and creative, motivate thinking, and be tied in with class activities. (Feb. 18/83)

In addition, in order to allow for a more relaxed student-teacher exchange, teachers needed to structure their environment in order to give greater flexibility and choice to their students. This they accomplished by giving some class lessons on the rudimentary aspects of the Logo language and programming, or on the topic that was being explored, such as geometric shapes; by designing activity or idea cards that were placed by the computer, from which students could choose freely; and by setting either fixed or open-ended challenges. All of these strategies helped to accommodate different levels of ability and different learning styles among students. A junior level teacher illustrated the need for such diversity and flexibility when, four weeks into the study, she wrote:

> Observing the kids these past few weeks has been interesting because it's obvious they use the computer in different ways. There are kids like Jim and Ken who follow my activity cards religiously and are thrilled to reproduce the designs. Donald and Bill know only a few commands, but they create wonderful designs. In their journals they ask me what they need to know to go on. Most of the kids do a mixture of these two styles: follow activity cards for a bit and then design. (Oct. 13/82)

Despite strong efforts to allow students to discover and learn as their needs demanded it, all teachers found that giving individual attention to all students at the moment it was needed was impossible with the large student-teacher ratio. If the computer was used throughout the day, chances were that the teacher was preoccupied with the rest of the class and could not interrupt that flow to accommodate questions from children at the computer. Teachers at all grade levels reported that it was very difficult to be aware of what individual students were doing at the computer at all times. For example:

> [Primary] I do not get to see what each group of children has done as I am usually dealing with another group. Unless they interrupt me (which they are not supposed to do) I only see the printout. This can be very frustrating for the children as well as myself. Hopefully, I see enough as most groups work through at recess or lunch during the week, that problems are usually ironed out. Also, of course, there is usually another student who knows the answer. (Jan. 14/83)
>
> [Intermediate] Observation is very incidental. Structured observation time is not possible because I teach all the time the computer is in use. It does not allow time to sit with the pupil and see his reactions, frustrations, errors. Often we only get the successes. Pupils seem reluctant to share time of low success. Casual observation, however, continues. (March 7/83)

The teachers who used the computer laboratory were not distracted by having to teach other subjects but they were unable to keep in touch with every student because of the large number of students in the class.

> [Primary-K] There are too many students and machines to get around to everyone. Too many students still need help with the four basic commands. I am so busy I can't spend long enough with each student to really observe rationally. When I can get to students individually, the interaction is good. Students often get frustrated because I can't get to them to help with their problems. I try to make them think things out as much as possible on their own. (May 12/83)
>
> [Junior] Thirty-three children in the computer room are really too many. I have about one minute to spend with each child and it is far too little. ... the demands for help and praise are massive. ... once a problem (bug) develops it is very frustrating for both the teacher and the student. (Feb. 8/83)

To compensate for the lack of time that could be given to students during regular school time, some teachers took on additional "homework" in order to assist students. For example, one intermediate-level teacher felt that:

> When pupils work so hard you must take time to listen to their concerns. ... It takes a lot of time to keep up with the pupils and check their work. The class or school timetables do not allow for this. This results in a lot of evening work to check disks, progress, etc.. (March 7/83)

Without exception, teachers found that a Logo-type computer environment demanded a great deal of their time. Some teachers encouraged students to explore independently in the manuals. This worked quite well at the beginning and developed a measure of independence in students. However, by the end of the first year and during the second year, even though there were additional Logo idea books available, students began to feel the need for other sources of inspiration. An entry in a computer journal by one of the junior-level students at the end of the first year revealed that students can get "stuck" without proper teacher input or support material:

> Lori and I were on the computer and we made nothing. Lori said why don't we make something out of the book but I said we did most of the things in the book, and she said ya. (April 19/83)

"Not knowing what to do" was a concern expressed by several students. In order to assist students with specific hardware or programming problems, almost all teachers used students as "consultants" for the day or week. This approach was found to be effective at all grade levels, including Grade 1. However, the use of students as "teachers" or "consultants" needed to be monitored. Students enjoyed assisting others for short periods of time; but when the "teacher"-student relationship extended over a longer period, relationships became strained. The "teachers" began to express concerns over losing their opportunities for learning new material. Entries by two junior-level students, Brent and Jeff, in their computer journals revealed the effect of time on that relationship [note that Brent joined the class on March 4, 1983 and Jeff was assigned to be his partner and "teacher"]:

> Brent - April 15/83: I type everything for Jeff he won't type but I like it. Jeff is a good teacher, he should get a trophy for what he taught me.
>
> Jeff - April 28/83: Brent is my favrit partner because I like to teach him new stuff and he likes me I guess that is just the touch I have with partners.
>
> Brent - May 27/83: On Wednesday, Jeff and I went on Word Processing and did our letters ... he was not helping me so I didn't get it right, so I said, forget it. I'm doing it on my own with class ... Mrs. Cook Jeff keeps on showing off and started becoming a total fool.

Over time, some students learned more quickly than others. In one intermediate-level classroom where challenges were set on the basis of "who can get it first", the more advanced students became increasingly reluctant to share their knowledge with others. The teacher of that classroom noted:

> There is a growing gap between the kids' knowledge, the faster kids are no longer willing to spend their time teaching someone else. They seem to feel that their classmates should struggle through it just like they did and find out for themselves. However they are still willing to go outside their classroom to help others such as grade 5 students. (May 18/84)

A more fundamental limitation, however, touched the "essence" of good teaching. If a student's problem was one of "not understanding", most "consultants" did not have the experience to remedy the situation. Just as one intermediate level-teacher reported that "I find it very hard not to intervene and to let them figure things out for themselves", junior-level students also reported about their teaching experience that:

> I wanted to do it for her instead of letting her figure it out.
>
> It's hard to know what is important.
>
> It's hard explaining so he understands.

Some students also said that they:

> Wanted to show off.
>
> Wanted them to think I was smart.
>
> I found it hard to just sit there and wait.

For example, one intermediate-level student reported:

> Steven was our teacher. He wouldn't show us anything. He would just come back and type it all in for us, so we didn't learn anything.

One junior-level teacher, who engaged her children in peer-teaching situations with two classes in the school, spent some time discussing with her students the role of the teacher, the need to engage a student's own thinking, and so forth. This sensitized some of the students to being a "good" teacher but others still expressed difficulties:

> Being the teacher is neat. The hardest thing about teaching is the student.
>
> Being the teacher is very boring. The hardest thing is explaining everything.

During the second year of the study, all three teachers who had first and second year students in their class expressed some difficulty in meeting the disparate needs of their students. Whereas during the first year, all students - including both grade levels in a split class - shared a common experience, this was not true during the second year. The "spare" time that two teachers used for exploring new ideas and strategies the previous year, was no longer available for computers since they had to cope with other new teaching responsibilities. The other teacher felt limited in his knowledge and concerned about advancing his students too much. All three teachers resolved their dilemma by giving the experienced students the responsibility to teach the inexperienced ones. The experienced students received only a minimal amount of input for their own growth. The reliance on "peer teaching" among the older students tended to reach a ceiling, in that students did not know where to look or go for additional input - beyond the manual and the limited support material that was available. Students in one of the classes began to take an active interest in the currently predominant computer culture: BASIC and video games. The absence of a diversified Logo culture outside the classroom, therefore, placed an extra burden on teachers since they had sole responsibility for creating a cultural framework for Logo.

When teachers were able to monitor or overcome some of these difficulties, both students and teachers expressed delight at being able to learn and explore together. Students commented that they enjoyed taking charge of their own learning, and sharing that learning with their teachers and other students. Several intermediate level students remarked that "time spent on the computer makes you more independent with your work". A junior-level teacher reported that her students also acquired a new sense of independence:

> Students tell me they have a problem; they don't usually say I'm stuck" or "I can't do it" or "I need help". These are usually said when problems are met in other areas. ... I come near the child who usually explains what he or she is trying to do. I suggest alternatives, or I say I don't know or I suggest checking with someone else who has had the problem. The child goes back to working on the problem. The point is that they seem to want to let me know they are having difficulties but don't necessarily want direct help. They are not afraid to keep trying. They are not totally discouraged either if they can't solve whatever it was right away. They'll shelve it and work at something else and go back to it later. (Jan. 20/84)

Teachers described their new relationship with students in the following ways:

> [Intermediate] I find that I am doing more individual teaching, i.e, one to one, because of the wide range of problems and levels of ability. Computing is an area of school work that the students share with me more and they seek to talk to me individually about it. It is a shared interest. ... I also find that timely intervention is necessary, because I often find kids doing things they don't understand, and an appropriate question will put them on the track. (Dec. 3/82)

> [Intermediate] The computer has created many opportunities for students and teachers to talk and help each other. Students ask for help more readily about computer-related activities than about other school work. Right now computer use facilitates rapport because it is regarded as a bonus and a special interest rather than as a mandatory part of the curriculum. There is no change in teacher's role with regard to students. (Nov. 12/82)

> [Intermediate] It provides many opportunities to share ideas, to question, to congratulate, to provide positive reinforcement. A great way to discover "thinkers" among our students! A new means of discovering the world of knowledge together. (Dec. 9/82)

> [Learning Disability Class] Often the teacher is expected to have all the answers; to act as instructor and aid. With the computer and Logo we were learning together; often times the children would discover something that they could show me. It provided experience in working together to solve certain problems. It became a team effort of equals for a time - was always a need for me there, whether to help, work with or just admire an accomplishment. This type of teaching experience is not always easy to come by and is very rewarding. (June 20/83)

> [Emotional Adjustment Class] Investigation and development as 'learner' promotes discussion and causes students to defend a point or to look further, knowing both himself and teacher are learning 'together'. (May 15/83)

It appears that teachers and students, individually and collectively, have experienced both joys and frustrations throughout this study. One primary teacher perhaps summed it up quite well:

> Fourteen computers and twenty students and one teacher can produce chaos, silliness, fighting, frustration, boredom, pride, interest, creativeness, sharing and fun for all involved. (May 15/83)

8. EFFECT ON STUDENT-STUDENT INTERACTION

There was unanimous agreement among teachers participating in the study that the computer can be a powerful facilitator of social interaction. To a large extent, this was due to the fact that most of the teachers not only permitted but actually encouraged students to learn from each other and to share their findings. This does not happen very often in the case of the traditional curriculum. As one of the teachers pointed out:

> The fact is that in most schools or classes, student-student interaction has been limited to extra-curricular activities which rarely deal with the basic issues of classroom life. Most instructional strategies emphasize teacher lectures and student seatwork. ... the most neglected variable in education, that of student-student interaction can be used in a positive way. Children enjoy learning from the teacher and each other. In order to get anything accomplished, co-operation is necessary. This basic exchange permeates every facet of the classroom. Logo is an excellent tool to use to promote student-student interaction. (May 15/83)

When students were offered the opportunity to learn together and to share that learning, most of them did so quite naturally, although the shy and insecure students needed some help in overcoming their fear of exposing their "ignorance". Others needed some time and coaching before they could engage in genuine sharing rather than "tooting their horn". Squabbles and conflicts occasionally arose but most students were so eager to work with the computers that they were willing to suspend or resolve most differences. Even when more persistent problems arose among partners, the social needs remained strong and did not push individual students into withdrawing from human contact, but rather to search for solutions or for a new partnership. For example, three months into the study one junior-level teacher reported that:

> These kids are becoming self-reliant to a greater degree than any other class. They are an average group of kids. They work together as partners much more willingly and with less friction than any other group of kids. In previous years a great deal of my counselling time was used helping kids work together positively. So far this fall, I have had two partnerships ask for help. (At least 5 or 6/week in previous classes.) (Dec. 13/82)

However, one month later she reported that:

> Several kids are complaining that the other does most of the typing or that they do all the work. (Jan. 14/83)

Several weeks later, she reported that students began to experience some of the complexities that can come from constant and close contact with one individual:

> I have two little girls (partners) whose bickering has become so intense I arbitrarily separated them. I am counselling. (Feb. 18/83)

These two girls resolved their conflict in the following manner:

> Jennie and Jackie have decided to try to work together again. Jennie says she is the only one who really understands Jackie, but she was concerned about what to do when Jackie was being particularly stubborn. ... They both seemed anxious to try a new working arrangement. (March 3/83)

Similar observations were made in other classes as well. One of the most common squabbles, at each grade level, arose over the equitable use of the keyboard. Many students enjoyed the mechanics of typing - although there were some who didn't - but control of the keyboard quite often meant control over the activity to be done or to be explored. Another common source of tension between partners arose when students were too far apart in their programming skills or interests. At the beginning, the more advanced students were quite happy sharing their knowledge with others, but then they began to express a need for their own advancement. The students who benefited from the help of the more advanced students, however, also expressed a desire to work with someone closer to their ability after a while. One intermediate-level student reported:

> I feel John was a very good partner and his skills are better than mine, but I feel that is fine for a change. I think I now need a partner of my own ability. (Feb. 3/84)

Some guidance by teachers was usually necessary when problems became serious. When problems with a partner could not be resolved, teachers encouraged splitting the time on the computer or changing partners. Students in most classes were free to change partners whenever they could make a suitable arrangement. On the whole, partnerships changed from a low of 7% in site 8ab to a high of 82% in site 9b (Table 9). The teacher of this latter site stressed that students should try to change partners at least once. Movement tended to be greater in situations or among groups where teacher input was relatively low. The majority of partnerships changed once with the exception of site 9(b,ab) where many students changed as often as five times. One student changed approximately twenty times, in order to "show or help more people and other reasons". Some of the common reasons other than personal tensions students gave for changing partners were:

I want to see what other people know that I don't know.

I felt I did not get my fair share of the keyboard.

I wanted to see what it was like to work with someone else.

I just needed a change.

I wanted to see what other people did.

It's boring to have the same partner all the time.

Everybody knows different things about the computers, so the more partners I had, the more tidbits about computers I learned and shared.

To get more help from different people.

I changed to someone closer to my ability so we could both learn together at the same pace.

I haven't learned that much to work on it by myself.

Because he knows what he is doing and I really don't.

Table 9

Responses to "Did you change partners?"

Site No.	5b	6b	6ab	8b	8ab	9b	9ab
No. of Respondents	23	18	10	14	15	17	14
				Percentages			
Yes	43	72	50	71	7	82	79
No	57	28	50	29	93	18	21

Analysis of "Yes" Responses:

				Percentages			
Changed once	35	44	50	71	7	12	0
Changed twice	4	17	0	0	0	12	7
Changed three times or more	4	11	0	0	0	58	72
Total	43	72	50	71	7	82	79

The danger of some students hiding behind their partner's competency or becoming too dependent on others was also raised by a Grade 2 teacher:

> Today there were four children each with one computer to themselves. A couple of them were not pleased with this. I think perhaps they needed some support or felt they wouldn't be able to work everything on their own. As it turned out, one girl on her own was not able to write a simple procedure. Many of the other pairs are continuing to work on procedures. (Jan. 25/83)

One of the junior-level teachers found a convenient way to keep on top of social as well as programming problems - through the use of a computer journal. At the end of each week, as part of their writing program, students were given time to bring their journals up to date. Students were encouraged to report on their activities, on any problems or questions that they encountered, to comment on their partnership, how they felt about working together, and to make other unsolicited comments. The teacher read these journals at her leisure and returned them with appropriate comments to the students at the beginning of the next week. The following excerpts from the journals of two partners offer some insight into the social dimension of a partnership:

> Mary:
>
> Nov. 9/82: Me and Allison had a real good time - made a face and a stupid looking thing. Allison wants to do stuff I can't do because she is more skilled so it is very hard to do this kind of stuff.
>
> Dec. 14: Allison is a big help when I get stuck. She knows everything about Logo.
>
> March 14: From now on Allison and I are splitting our computer time; that way she can do her thing and I can do mine.
>
> April 11: Allison and I cleaned up our disk. Then Allison made a read list. It's funny.
>
> April 15: I really need to catch up with Allison. When Allison has her own time on the computer can I watch?
>
> April 18: I got tired of always going on the computer so I didn't do anything.
>
> Allison:
>
> April 24/83: Thank you for the free time on the computer, now I can do things that is further than Mary and she won't get confused.
>
> Mary:
>
> May 27/83: BSW this week was boring. I had to fix my plot and my story. Allison's story is really exciting! I always have boring stories.
>
> June 13: I had a genius for a partner.

The teacher described this partnerships as follows: "Mary is so bossy and Allison's so easy going. I just enjoy watching them." Despite such personal differences and problems, when students were asked at the end of the study if they enjoyed working with a partner, 78% to 86% answered "yes" or "sometimes" (Table 10). Teachers at every grade level reported enthusiastically on the high degree of social interaction among students. The following quotations were only a small sample of those recorded by teachers or researchers:

> [Primary-Grade 1] Children are proud of their accomplishments. They rush to show teacher and peers. There is a great deal of sharing of procedures - to produce the same pictures as others. (May 15/83)
>
> [Primary-Grade 3] Social skills have improved. Children soon realize that to accomplish anything worthwhile they must work together. (Dec. 15/83)
>
> [Junior] Because the child usually works with another child when programming in Logo, the positive feelings he has about the product seem to spill over into his relationship with his programming partner. There is very little aggressive behaviour shown in or out of my classroom amongst the children. There are disagreements, angry feelings, etc. but the children seem to feel a sense of confidence that these can be worked out somehow. (Jan. 13/84)
>
> [Intermediate] Computer is a powerful way for a teacher to observe crucial social behaviour and values. (June 3/83)
>
> [Intermediate] It (Logo) provides many opportunities for sharing ideas, for co-operation, for understanding of another person's way of thinking (especially if they are sharing the computer with another person); great opportunity to compromise and develop good social skills. (Dec. 17/82)
>
> [Intermediate] Children more readily ask each other for help with Logo problems than with other school work. (Dec. 3/82)
>
> [Intermediate] Some students have chosen to stay with the same partner and others changed. Students are eager to look at the work of others. At the outset they did so in order to gain security and ideas. As students gained more confidence, they began to share

Table 10

Responses to "Do you enjoy working with a partner?"

	Frequencies		
	Primary	Junior	Intermediate
Yes	48 (80%)	15 (54%)	58 (75%)
Sometimes	3 (5%)	9 (32%)	2 (3%)
No	8 (13%)	4 (14%)	15 (19%)
No answer	1 (2%)	0	2 (3%)
Total	60 (100%)	28 (100%)	77 (100%)
Analysis of "yes" responses:			
We help each other	17 (28%)	8 (28%)	26 (34%)
Sharing, knowledge, humour,company	10 (17%)	1 (4%)	17 (22%)
Generates more ideas	4 (7%)	5 (18%)	14 (18%)
No explanation	17 (28%)	1 (4%)	1 (1%)
Total	48 (80%)	15 (54%)	58 (75%)

Table 11

Responses to "Would you have liked to have worked alone?"

	Frequencies		
	Primary	Junior	Intermediate
Yes	35 (58%)	22 (79%)	31 (40%)
No	24 (40%)	5 (18%)	40 (52%)
Don't know	1 (2%)	0	0
No answer	0	1 (3%)	6 (8%)
Total	60 (100%)	28 (100%)	77 (100%)
Analysis of "yes" responses:			
Do own thing; can explore better	18 (30%)	20 (71%)	24 (31)%
Get more done and quicker	4 (7%)	0	7 (9%)
Concentrate better; more quiet	4 (7%)	0	0
It's fun; not so crowded	3 (4%)	1 (4%)	0
No explanation	6 (10%)	1 (4%)	0
Total	35 (58%)	22 (79%)	31 (40%)

> their new ideas or the various "neat" designs that they had created. There is usually someone (or more than one) who is eager to share that enthusiasm and joy. (Dec. 17/82)
>
> [Learning Disability Class] The computer had pairs working together that would have been unlikely. Usually one close friendship evolved from this. (June 15/83)

The sharing of ideas or of resolving differences did not come as easily to the students of the junior behavioural adjustment class. These students tended to be verbally and physically more aggressive and they were very protective of what they were doing. An entry in the researcher's notebook at the beginning of the study gave the following details:

> These students cannot work together for any length of time without getting into a fight. They are very possessive and don't want anyone to do the same thing as they are. Consequently these boys work individually at the computer. When any child comes over to see what they are doing they cover the screen with their hands. There is no sharing of ideas in this classroom. (Nov. 12/82)

However, five weeks later the teacher was able to report that:

> Students have begun to share some activities, particularly in music, which is a large step. Behaviour in groups is not yet to the point where work is effective.

By the end of the school year he reported that "times are developing when the whole class shares experiences".

Although students indicated that they generally preferred working with a partner, when they were asked if they would also have liked to work alone, 58% of the primary grades, 79% of the junior grades, and 40% of the intermediate grades responded in the affirmative (Table 11). The tensions between interdependent needs and individual needs of students tended to be between a desire to help and to be helped, and to do "one's own thing"; a desire to share and to get on with the task; and a realization that "two creative minds are better than one" and the need to "see if I can do things on my own". A cross-sectional sample of reasons that students gave for wanting to work alone or with a partner, drawn from all grade levels, offers some insight into the nature of these tensions. Reasons for wanting to work alone included:

> Partner wouldn't bug me, push me around and make mistakes.
>
> Wouldn't fight over what to call procedures. I like the freedom.
>
> I would like sometimes to show what I can do not what my partner and I can do.
>
> Because I would get the trouble and the credit for everything I did.

> I'd just like to complete something by myself so I could take all the credit for it.
>
> It would be weird to work by myself and to see what I can do and what I have forgot.

Reasons for wanting to work with a partner were:

> Both make each other good things.
>
> If you don't know how to spell a word your partner might know how.
>
> Not so lonely and typing and typing; maybe your hands will swell up if you have to do it all alone.
>
> I feel important helping my partner.
>
> I feel I learn more with Jane helping me.
>
> I like working with a friend because it helps you from being bored.
>
> I don't feel so alone and scared that I won't get it.
>
> I haven't learned that much to work on it by myself.
>
> One could think and the other could type so it took less time to do more stuff.
>
> Because we can joke together and I think also I learn more.
>
> Working with a partner helps to communicate.
>
> If one doesn't know the direction the other one might and if you both don't know you can work it out together.

The computer activities allowed old perceptions among students to be re-evaluated. For example, some students who did not make an impact on their peers before, emerged as a "whiz" on the computer. One intermediate teacher wrote:

> Social interaction is good. Pupils are really getting to know each other. They are starting to form respect for pupils based on the computer rather than other school activities. That's not to belittle other activities but it's great to see kids accept each other for a new set of values. (Oct. 16/82)

Students discovered quite early, even at the Grade 1 level, who was most knowledgeable on the computer. These students quite informally became the "computer consultants" in the class. Some of the teachers formalized this situation and designated a "consultant for the week" or assigned a "consultant" to be responsible for one pair of students in order to give more students a position of status. Other students were given "status" in a different way. For example:

> [Primary-Grade 3] Craig is odd man out in most social situations and was not picked by anyone to be a computer partner. He is a slow student, not very well groomed, shy and has tended not to get involved with other kids. I have allowed him to pick a classmate to work with him when it is his turn. Since this is extra computer time for whoever he chooses, he has lots of willing volunteers to choose from. He has made some new friends and is much better appreciated by his classmates since they've had an opportunity to get to know him. (Oct. 27/83)

With the increased confidence and knowledge, some students became concerned about receiving recognition for their own original creations and they became protective of what they had done. One Grade 3 student reported: "I don't want anyone taking my skyline and changing it. I like it the way it is." Two teachers reported that:

> [Junior] Another problem is plagiarism of procedures. Some kids pirated the procedures and designs created by others. Several kids signed the "problem" section of the sharing list complaining that others had used their designs without permission. Many angry feelings came out in discussions over several days. Finally it was decided to take one suggestion - to post a list of those who minded others "borrowing" designs and a list of those who didn't. (Jan. 30/83)
>
> [Intermediate] Some children are very protective of their discoveries ... sharing for some is difficult. (March 7/83)

The problem of ownership and sharing was resolved more easily in a classroom atmosphere where co-operation was stressed and encouraged. In the class where rewards such as "stickers" or names or samples were displayed whenever a person was the first to solve a challenge or assignment, students were less willing to share and ownership of ideas became much more important.

All teachers in the study extended the student-student interaction in the classroom to other students in the same school or beyond, which became a powerful means of breaking down traditional barriers between grades. In part, this was possible because computers were not available to everyone and the students in the study shared a scarce resource with others. The impact was particularly striking in the emotional adjustment class. Whereas previously, this class was rather ostracized by others in the school, the computer brought curious students to the door. The teacher encouraged such interaction and his students became teachers of others on occasion. Rather than being seen as "odd", students were gradually being seen at a closer personal level. A junior-level class that taught Grade 4 and Kindergarten students in their school were sensitized to "being a teacher" through prior discussion and role-playing, where students took turns being the "student" and the "teacher". Students also participated adapting "K-logo", a version adapted from Instant Logo, so that it would "make sense" to the very young. Also, before the older students worked with Kindergarten students on the computer, they visited each other's classroom, shared common play activities, and read stories together. Some of the students' reaction to this experience were:

> I enjoyed working with kids. I love seeing the expression on their faces when they were able to accomplish something.
>
> I enjoy teaching the little kids but it get boring just sitting there.
>
> Yesterday when I was walking around the school the Kindergarten children weren't shy. They were saying "hi" to the kids in my class.
>
> It makes us feel grown-up and like a teacher.
>
> I was surprised at how much they know for their age.
>
> K-logo was fun. I really enjoyed it. I never really understood how careful and sensitive you have to be with Kindergartens.
>
> Working with my kids I found that it is not as easy as it sounds. I forgot that I was working with little kids and they don't understand as much as we do. At first I expected them to come back the second time and not remember everything I had taught them but I was surprised when my little girl remembered most of all the things I had taught her.
>
> Teaching with kids taught me that I can teach and handle little kids. It taught me a lot! I taught my kids right from left and a few days later they still knew right from left. I think I'm a pretty good teacher.
>
> I don't like working with K children; too young. I want my own time again.
>
> My kid in the morning is a brat, I don't like him.
>
> I don't really like the idea of having little kids. The morning kid was not so smart. He did a lot of dumb things. The afternoon kid does seem smart for a Kindergarten.

Another junior class experienced an exchange with a class of slow learners to whom they were teaching a simplified version of Logo. Again, before the actual exchange took place the students learned about mental retardation: the causes, manifestations, learning problems, and limitations. The students cooked together and worked at the computer together.

The computer activities, therefore, became a powerful medium for exploring social skills, communication skills, and problem solving skills based on real needs, not on hypothetical situations that had no bearing on the students' immediate interests. No longer was it necessary to "create" situations or "kits" for such purposes. Most teachers were impressed with the degree to which students developed these skills even though, during the process, real feelings of anger, jealousy, anxiety, and competition flared up. These skills were honed in all grades, even the youngest. For example, junior-level students reported that:

> Tracy and me both like typing. We sometimes get into fights but we always solve them. (May 6/83)
>
> My partner and I argue sometimes but we do a lot of good things. (Dec. 14/83)
>
> Well you know how last week I told you that I was typing too much. Me and Kevin solved it. (Jan. 21/83)
>
> Could I pleeease have Ken. R. for my partner. He's seemed to smarten up now. I guess we just had to stay away from each other for a few months. I wrote this because I thought you might think that me and Ken R. still hate each other and put me with another person. (Sept. 7/83)

Teachers or researchers reported that:

> [Primary-Grade 3] Leonard and David are getting along well. I asked "Why do you think you boys work so well together?" To my surprise they looked at each other and laughed: "We don't; we fight good". (Jan. 11/84)
>
> [Primary-Grade 3] The children get together with their partner each Friday afternoon and discuss when, during the next week, they are free at the same time. They get 20 minutes every other day in a six day cycle. (Feb. 11/83)
>
> [Primary-Grade 3] A "give and "take" situation has developed with most groupings. I see discussion instead of argument tolerance, restraint, respect for each other's point of view. Very much a "share" situation. In the two groups where argument is still going on, more time is spent discussing than arguing. Not so much "blame" is being attached to one person or the other. (Dec. 15/83)
>
> [Junior] More recently they have begun to reorganize partnerships for computer time, based on shared interests. This couldn't be done as well from the outside by a teacher. (March 10/83)
>
> [Junior] I am very pleased that these kids are developing to the point where they not only see that change is necessary, but are able to work out their problems in a positive acceptable way. ... They are developing social skills many adults do not possess and they really care about each other. (March 3/83)

Most partnerships, at all grade levels, tended to be of the same gender. Boy-girl partnerships that did exist tended to be of short duration. Journal entries in a junior-level class gave some insight into one such mixed partnership. The boy recorded the following:

> Jan. 11/84: I liked it [working with Allison] because she says OK all the time not NO or I DON'T WANT TO and she's really nice and has got a nice personality.
>
> Jan. 13: Well I am not sure if she wants to type or not because she isn't getting her fair share.

The partnership broke off three weeks later and the girl recorded her reaction to this partnership as follows:

> Feb. 7/84: It [working with Irvin] was boring. Irvin did all the typing and I just sat and watched him. I wanted to do something of my own.

The fact that Allison was the most knowledgeable student in this class may have been one reason why this boy, who was very eager to learn more about Logo, was interested in "pairing" with her now and then. Particularly noticeable was Allison's change in behaviour from being an active partner in a girl-girl pairing (refer to the exchange between Mary and Allison on page 73) to being a passive one in this boy-girl pairing. Another boy-girl partnership (at an intermediate-level) that lasted for an extended period was with a boy who did not enjoy the competitiveness of the other boys in his class. Other mixed gender partnerships at the intermediate-level that lasted for short periods of time did exist. The girls' reactions to such mixed pairings were expressed as follows:

> I really like working with my partner because we both have the same ideas and can work on it together. It doesn't bother me that he is a boy. (May/83)
>
> I partnered a boy for a while and hardly got to do anything. I touched the keyboard maybe twice in two months. (June/84)
>
> I also worked with a boy for awhile and we always had to do boy stuff, like hockey sticks. (June/84)
>
> If you go on with a boy. they will usually ignore you totally. If you say anything, they say "you've got to be crazy". (June/84)

The boys' impressions were:

> When we had boy-girl computer partners some of us boys used to hog it from the girls, but it hasn't been so bad recently. The girls just do silly designs. (June/84)

> Judy only wanted to fool around and never work on a good program that would take a long time to do. (June/84)

In most classes, it appeared as if male and female students were quite willing to share their knowledge with each other even though they did not work in close partnerships. However, in one of the intermediate classes, boys and girls reported that a definite schism developed between them, especially towards the end of the second year of the study (see Chapter 10 for a more detailed discussion). One girl summed up the boy-girl interaction in that class in the following way:

> Sometimes they [boys] are good friends, but when it comes to computers they are sharks. They like to show off. They think they are better than everyone else. (June/84)

Despite these "tugs of war" between students of the same or opposite gender, all teachers - with one exception - actively campaigned to have computers in their classrooms again. For example, the teacher from the emotional adjustment class who, at the outset, was the greatest skeptic and was very reluctant to become involved with computers because he was afraid that it might have a dehumanizing impact on people, had the following to say by the end of the study:

> My initial fears of social problems is almost completely turned around. The computer has offered a channel for interaction with other students in regular classrooms. The computer is an excellent reinforcement. The problems and frustrations are greatly outnumbered by the positive aspects. (Feb. 15/83)

He went to great pains to explore every avenue and possible source for funds so that he would have a computer in his classroom beyond the duration of this study. He reported that he had not gone to such lengths to obtain any other teaching support material or system before.

9. EFFECT ON STUDENTS' CONFIDENCE AND SELF-ESTEEM

The most immediate reaction by teachers in this study to having access to computers for their students was to relate anecdote after anecdote about the positive effects that the activities on the computers had on their students' self-esteem and sense of achievement. For example:

> [Primary-Grade 1] I had a little boy whom I tried to teach numbers last year in the traditional ways. He couldn't do them. Now on the computer he could learn 0 to 10 in the first week. When it became a meaningful thing, he retained it and experienced success. (Nov.8/82)
>
> [Primary-Grade 3] A real plus for some children. For example, Jamie, a very quiet boy has become a person. For the first time he feels that he is important. Previously it was very difficult to get him to talk about anything, but now he loves to talk about the computer and his work on it. The remedial teacher has commented that he is a different child. (Nov. 10/82)
>
> [Primary-Grade 3] Craig, who has very little self-esteem and no friends, has begun to realize he does know something. He did a "show and tell" of a picture he had made and answered questions asked by the class. He was very proud of his accomplishment. The other children were surprised at Craig's success. On the other hand, Leonard, who has too much self-esteem, discovered he was not better than some of the others after all. He could not do some of the "neat" things they were doing! He is a much quieter and more likable child now. (Dec.15/83)
>
> [Junior] John, described as hyperactive and mathophobic, who has had a very unhappy school experience, is confident with the computer and has produced one of the more spectacular pictures. (Nov. 12/82)
>
> [Intermediate] Russell was the first person in the class to write a procedure to make a circle. The whole class watched as Russell made the circle. The kids grilled him with questions on what and how to do it. He was a hero for a time. For Russell this was a breakthrough. The computer is becoming a reason to enjoy school and complete work. He is a real sharp boy. (Sept. 16/82)

> [Learning Disability Class] In LD kids there is a large discrepancy between verbal and performance ability. One boy in particular is doing exceptional work with graphics. He has discovered an area where he excels the class. This was not so before. This has been an enormous help to him. Self-concept is important to these kids who have been frustrated with school so often and for so long. (June 15/83)

Although teachers predominantly related anecdotes about students whose prior school experience was not a positive one, they did acknowledge from the outset that access to computers had beneficial effects for all students. For example:

> [Junior] Every child seems to produce work he/she is proud of. The affective climate of the classroom is my top area of concern. The computer is an excellent tool for this purpose. ... Different learning styles are very evident but aggressive and confident, or timid and needing direction, all seem to get satisfaction from their efforts. (Nov. 12/82)
>
> [Junior] It has a positive effect on most students. They all can create something. For the more advanced, it offers an opportunity to help someone else. (Dec. 17/82)
>
> [Intermediate] It (activities on the computer) increased self-esteem and selfconfidence; to put it in a student's own words:' everything is so beautiful on the computer'. (Dec. 9/82)

Further evidence that computers did have an impact on students' general level of confidence came from the students themselves. At the end of each of the two school years, students from the junior and intermediate classes were asked whether working on the computer had affected the way they felt about their abilities in general. Responses to this question (Table 12) revealed that 57% of the students in the study during the first year and 53% of the students in the study during the second year reported an increase in their general confidence level.

Table 12

Responses to "Has Working on the Computer Affected How You Feel About Yourself?"

Site No.	6a	6b	6ab	7a	8a	8b	8ab	9a	9b	9ab	10a	11a	13a		Total
Grade	5	5/6	5/6	5	6/7	7	7	7/8	8	8	8	8	SLD	1st yr. students	2nd yr. students
Number of Respondents	26	20	10	27	26	15	16	30	17	14	16	23	6	206	40
								(In percentages)							
I feel much more confident about my abilities in general	46	25	30	30	20	27	19	0	6	0	12	13	33	21	15
I feel more confident about my abilities in general	31	35	50	0	64	47	50	37	23	14	44	48	50	36	38
No change	12	25	20	56	12	20	31	57	65	86	44	35	17	36	47
I feel less confident about my abilities in general	4	0	0	4	4	0	0	0	0	0	0	4	0	1	0
I feel much less confident about my abilities in general	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0
No answer	8	10	0	10	0	6	0	6	6	0	0	0	0	6	0

The impact on the students at individual sites, however, differed significantly from a low of 14% at site 9ab to a high of 84% in site 8a. Possible reasons for this difference will be explored later. Analysis of these responses with respect to the students' academic standing, as reported by the students at the beginning of the year, showed that a substantial proportion of students (regardless of academic standing) experienced an increase in their general confidence level (Table 13). Again, the impact varied greatly among sites but, on the average, among students in the study for their first year (referred to as first-year students), the academically high achieving students fared better (68%) than the average (46%) or low achieving students (54%).

One possible explanation of why academic high achievers also experienced a significant increase in their general confidence level was given by one of the primary teachers, and echoed by teachers from other grade-levels, namely, that at the outset:

> The shyer, less aggressive better academic students tended to be afraid of trying new things. The lower academic students, the ones who are more aggressive or those who have difficulties (behaviour problems) really seem to "take off" with Logo. They aren't afraid to take risks and try things. They, therefore, often get better results than the model students (perfectionists) who hesitate more and are more worried about whether they are right. (May 12/83)

The "perfectionists" needed to be assured that exploring ideas was a legitimate activity even if it did not result in "success" or a finished product right away. The non-judgmental atmosphere that most of the teachers created around Logo activities helped all students gain more confidence in exploring and tapping their own creative ideas. Teachers reported that:

> [Primary] Because there is no definite goal or concept you are trying to achieve, the interaction between yourself and the student is less tense. You assist them in an inquisitive and excited way because in many cases, you, as the teacher, are not sure how things will turn out either. (May 12/83)
>
> [Primary] Constant interaction - problem solving or just a pat on the back for a design well done. Non threatening interaction - we are all learning. New ideas, skills, concepts. Children are certainly seen in a new light when sitting at a computer keyboard. I find it interesting the things they find it important to create. (April 5/83)
>
> [Junior] There appears to be a strong positive effect on self esteem. It appears to be due to the "no-lose" situation involved in learning to programme in Logo. ... His accomplishments are set in a relatively tension free atmosphere, as they are relatively non-teacher directed and non-teacher interferred with. (Jan./84)

Table 13

Students' Academic Standing at the Beginning of the Year and the Corresponding Change in General Confidence Level at the End of the Year. (Numbers in Percentages)

	Academic Standing								
	Mostly A or A&B			Mostly B or B&C			Mostly C,D or B&D		
		Gen. Confidence			Gen. Confidence			Gen. Confidence	
	%. of class	positive change	no change	%. of class	positive change	no change	%. of class	positive change	no change
Site 8a (N-25) Grade 6/7	84	90	10	16	50	50	0	-	-
Site 8b (N-14) Grade 7	36	80	20	64	78	22	0	-	-
Site 8ab (N-15) Grade 7	67	70	30	33	60	40	0	-	-
Site 9a (N-29) Grade 7/8	48	50	50	42	42	58	10	0	100
Site 9b (N-16) Grade 8	25	25	75	44	0	100	31	80	20
Site 9ab (N-13) Grade 8	77	10	90	8	0	100	15	50	50
Site 10a (N-16) Grade 8	94	60	40	6	0	100	0	-	-
Site 11a (N-23) Grade 8	30	71	28	57	54	46	13	67	33
Total									
1st yr.students (N-123)	54	68	32	37	46	54	9	54	46
2nd yr.students (N-28)	71	40	60	21	50	50	8	50	50

> [Intermediate] The computer allows students to explore without fear. Any errors can be erased and corrected to present a perfect final product. It promotes exploration and investigation, usually with a new "find" to share and be proud of. (May 12/83)

Entries in students' computer journals also revealed how important this was to the students themselves. Some typical reactions were:

> [Primary - Grade 3] Learned that if you make a mistake you try again. (June 3/83)
>
> [Junior] I feel free doing Logo because no one is there to boss me around - tell me what to do. (June 3/83)
>
> [Junior] I feel happy when I'm doing Logo because I can create something new every time I go on the computer. (June 3/83)
>
> [Junior] We were just fooling around and we made it. I think that's neat how that happens. (Jan./83)
>
> [Learning Disability Class] I think the computer helps me to concentrate on my work because now nobody bugs me when I'm at the computer. Sometimes I take my whole period fixing the things that I'm working on and it is a lot of fun and the thing I really like about it is you just can sit down and know what you want and you have a world of your own and that makes me feel great. (May 18/83)

The students who were considered behaviour problems and some of the students who had low academic scores could easily have needed a more challenging outlet. Some of the teacher's "surprises" stemmed from the notion that academic performance is equivalent to intellectual ability. This is not always the case. For example, of the fourteen students in the intermediate classes who recorded an academic standing of mostly C's and D's, four considered themselves above average, eight as average, and only two as below average relative to other students in their class. Although there was a chance of self-deception, such discrepancies are frequently reported in the literature on the underachieving gifted. One student in a primary grade who, prior to the study, was considered to be average, was recommended for enrichment programming on the basis of her work with the computer. Other teachers treated some of the "outstanding" work of students who were not achieving academically as interesting anomalies and did not take any further action in changing those students' regular school work. For these students, the computer activity became at least one "reason to enjoy school" and to find a meaningful place for themselves in the classroom.

The freedom that some students felt while working at the computer was related to gaining control over their own activities. This notion of "being in control" was extended further to "having control over". Several students commented that they enjoyed having control over the turtle. One intermediate-level student gave a very graphic description of this:

> Interesting and exciting to control the turtle. It takes the directions we give it and since it understands the language it does them just like telling a dog to sit and beg. (Nov. 17/82)

The computer - especially Logo - seemed to be a good medium for encouraging students to explore and to experiment. Logo was found to be an easily "accessible" computer language and students received very quick feedback. Also, in turtle geometry "neat" results could be achieved even when mistakes were being made. Students found this very compelling. Three students recorded in their computer journal:

> [Junior] I have accomplished lots and lots of freaky and fantastic designs. I feel proud of my work on the computer. (June 3/83)
>
> [Junior] Sometimes you even have fun when you have problems. (June 3/83)
>
> [Intermediate] Sometimes its fun experimenting by yourself. (March/84)

Another possible reason why students often received a boost in their overall confidence level was the new sense of task committment. For example, students reported that:

> [Primary-Grade 3] This picture was very hard and it took me 1 hour and 20 minutes to do it but it had to be done. I liked doing it. (March 8/84)
>
> [Primary-Grade 3] We did this picture a while ago when it was snowing. We decided to put some music and a question with it. It took hours of work because we kept on getting muddled up but we finally got finished. (June 11/84)
>
> [Junior] I made a gun to shoot at a target. Took a long time but it was worth it. I was so excited ... I thought it was the best thing on earth. (June 3/83)
>
> [Learning Disability Class] Sometimes I felt like to pick it up and throw it out the window because I would do it and it would be wrong and I would have to look for the mistake in the edit mode but I had a lot of patience to do it. It made me realize that computers can help me in my learning. (May 19/83)
>
> [Learning Disability Class] Sometimes it took a long time to finish a thing but I loved the excitement of seeing the final result. (May 19/83)

Students were also able to engage in thinking processes that gave them new and additional insights into their mental abilities. One junior-level student succinctly summed it up for many other students: "I like the computer because it makes you think." When students from site 10a were asked at the end of each of four computer sessions what specific activities they enjoyed best and why, of the fifty-two responses:

- 40% referred to activities that they perceived as hard, challenging or from which they learned a lot;

- 38% referred to activities they found interesting, novel or that simplified ways of getting interesting results;

- 15% referred to activities they found "neat" to experiment with or which allowed them to examine an idea or task in several ways; and

- 7% referred to activities they had done before but explored anew.

When asked what activities they liked the least, 41% indicated that they found nothing to dislike. The 59% who reported that they disliked some of their activities gave the following reasons for doing so:

- 73% of the reasons were related to activities they found to be boring (even if the activity was initiated by the student), demanded doing the same thing for too long a period, doing something that was already familiar, or doing something that lacked variety in the task, and

- 27% of the reasons were related to a lack of success - goals that were either set by themselves or by the teacher.

During the second year of the study, students in sites 6(b,ab), 8(b,ab) and 9(b,ab) were asked to record, on an ongoing basis, if they enjoyed their Logo activities at the computer and why. Of the 467 responses to activities that students liked (81% of total responses collected), 37% mentioned the words "challenging" and "something new". However, 30% also mentioned that specific activities were "fun". Of the negative responses (19% of the total), 58% dealt with boredom or nothing to do, 15% with activities that didn't lead to success either because it was too hard or there was not enough time, 9% dealt with a variety of idiosyncratic reasons (including mechanical failures), and 18% could not give any reason why they didn't like the activity. Since the notions of a challenge and fun are rather personal, it was found that a challenge to one student may not be one to another; and that without eventual success, an activity could lead to unresolved frustration. As indicated previously, of the activities students disliked 27% in site 10a and 15% in sites 6(b,ab), 8(b,ab) and 9(b,ab) were due to a lack of success. One student who struggled without success at an assigned task for about one hour, began to complain of a headache and during the next session did not want to work at the computer at all. Two intermediate-level students in another class who were struggling with one assignment for one week finally gave up:

> We worked all week on it [assignment] and we don't get nothing. I ain't going to do it no more. (Jan.16/83)

Although the actual work at the computer had an impact on students' general confidence level, this impact was not entirely dependent on how confident students felt about their ability to work with computers, nor how well students did at the computer in terms of programming skills. For example, approximately 60% of the students who had been in the study for one year expressed a positive change in their general confidence level regardless of how confident they felt about working with computers at the beginning of the year (Table 14). Greater differentiation occurred with time in favour of those who experienced an increase in their confidence to work with computers. However, 44% to 58% of the students who either experienced no change, or a negative change, in their perceived ability to work with computers still recorded an increase in their general confidence level (Table 15). Additional factors that transcended the actual performance on the computer were therefore instrumental in affecting students' general confidence level.

One such factor was the social context, both within and outside the class, in which the computer activities took place. For example, teachers wrote:

> [Primary] During the period of Feb.7 to Feb. 18, we spent 120 minutes in the computer room doing Logo. None of the children were successful at the given task of trying to draw a particular picture today. Nevertheless, the children are always proud of their accomplishments and eager to show off to both myself and peers. (Feb. 18/83)
>
> [Intermediate] Children feel more confident and competent. They feel more capable of doing things because they get feedback from their friends who are impressed with the fact that they can do something on the computer. (Dec. 3/82)
>
> [Adjustment Class] The computer is the one thing that the boys are really enthusiastic about. With most things they lose interest pretty quickly. They have just started to write to pen pals in a school in Yellowknife and the first thing they wanted to tell them was that they had a computer in the classroom. (March 21/83)
>
> [Intermediate] When Susan ran the procedure it didn't draw the design that she had in mind. She was rather intimidated by this. However, two other students saw the design and commented how lovely it was. This helped Susan to accept her own mistake and to continue experimenting with other procedures. (Dec. 7/82)

A second factor was related to how other people in the students' environment perceived the computer. Computers are still considered to be a novelty, and many adults are impressed by the fact that children know something that is unfamiliar and even frightening to them. For example, junior-level students recorded in their journal:

> I feel important when I do Logo because there are not many people doing this. (April 2/83)
>
> I feel better about myself because my parents say I am a computer whizz. (March 7/83)

> Visitors make you feel like your class is important. (May 10/83)
>
> I like having visitors in the class. It sort of gives you a chance to show off. Some people think that kids can't do much but this way we can show them that kids can do a lot. (April 5/83)

Many students were able to demonstrate their knowledge to other students and adults at their school's "open house" and at displays in nearby shopping centres. Students' comments were:

> [Junior] I felt very comfortable at the computer fair. I love doing things I know I have learned. ... I felt glad when I heard people make good comments. (March 27/83)
>
> [Learning Disability Class] I have taught grades 1 - 5 about computers. I've done neat stuff on the computer whenever I can. (May 18/83)

A third factor involved student-adult relationships: for the first time some students had a chance to see adults struggle with learning something new. Some students were even given the chance to teach Logo to teachers. For example, one of the intermediate-level teachers found the following letter on one of his demonstration disks:

> Dear teacher/parent:
>
> This is a day set apart for your Professional Growth and we most appreciate the holiday but we would like to encourage you as well.
>
> Today you are studying computers. We know that this new tool takes time and energy to master. We know that our teacher has spent a lot of time learning about them so we can share them this year. Its not hard to see the frustration he sometimes suffers as he learns new things. You probably feel it too. Our teacher will find this on his word processor disk and we hope that he will share it with you.
>
> We also suffer as we learn. New lessons are always hard at first. This year we have learned that the COMPUTER is an important part of our future. Please learn well about this new tool. Share your experiences with us. Our future depends on it.
>
> Sincerely
>
> A student
>
> P.S. Thanks Mr. O, for getting us started. I hope we didn't mess up your disk.

Table 14

Students' Perceived Ability to Work on Computers at the Beginning of the Year and the Corresponding Change in General Confidence Level at the End of the Year.

(Numbers in Percentages)

	Confidence Level								
	Confident			Not confident			Don't Know		
	%. of class	positive change	no change	%. of class	positive change	no change	%. of class	positive change	no change
Site 6b (N-18) Grade 5/6	100	67	33	0	-	-	0	-	-
Site 6ab (N-10) Grade 5/6	80	88	12	0	-	-	20	50	50
Site 8a (N-25) Grade 6/7	24	83	17	24	67	33	52	92	8
Site 8b (N-13) Grade 7	84	82	18	8	0	100	8	100	0
Site 8ab (N-15) Grade 7	73	73	27	0	-	-	27	50	50
Site 9a (N-29) Grade 7/8	72	48	52	10	67	33	17	0	100
Site 9b (N-16) Grade 8	63	30	70	25	50	50	12	0	100
Site 9ab (N-15) Grade 8	60	22	78	27	0	100	13	0	100
Site 10a (N-16) Grade 8	62	60	40	0	-	-	38	50	50
Site 11a (N-23) Grade 8	87	60	40	0	-	-	13	67	33
Total									
1st yr.students (N-140)	69	59	41	10	57	43	21	60	40
2nd yr.students (N-40)	70	61	39	10	0	100	20	37	63

Table 15

Change in Students' Perceived Ability to Work on Computers From the Beginning to the End of the Year and the Corresponding Change in General Confidence Level at the End of the Year.

(Numbers in Percentages)

Change in Computer Ability									
	Increase in comp. ability			No change in comp. ability			Decrease in comp. ability		
	%. of class	positive change	no change	%. of class	positive change	no change	%. of class	positive change	no change
Site 6b (N-18) Grade 5/6	6	100	0	44	50	50	50	78	22
Site 6ab (N-10) Grade 5/6	50	100	0	30	33	67	20	100	0
Site 8a (N-24) Grade 6/7	88	86	14	8	100	0	4	0	100
Site 8b (N-13) Grade 7	15	100	0	62	75	25	23	67	33
Site 8ab (N-16) Grade 7	0	-	-	88	64	36	12	100	0
Site 9a (N-29) Grade 7/8	21	33	67	55	62	38	24	0	100
Site 9b (N-16) Grade 8	38	50	50	50	12	88	12	50	50
Site 9ab (N-14) Grade 8	7	0	100	57	12	88	36	20	80
Site 10a (N-16) Grade 8	44	57	43	50	62	38	6	0	100
Site 11a (N-23) Grade 8	9	50	50	65	67	33	26	50	50
Total									
1st yr.students (N-139)	32	69	31	47	58	42	21	45	55
2nd yr.students (N-40)	15	83	17	63	44	56	22	56	44

A fourth factor involved the psychological or emotional release that students found in their computer work. For example, a junior-level teacher who allowed her students free choice over their computer activities found, at the end of the first year, that two students tended to let others do the programming while they watched, and four were still extensively doing wrapping designs at the end of the year. This teacher, however, pointed out that these students derived other significant benefits from watching or doing simple repetitive tasks:

> One boy was afraid to take chances; he let others program for him; he copied what others did but he really liked to write about what he did on the computer. (May/83)
>
> Susy was suffering through home problems and she was often too distracted to do coherent work. Doing simple designs using wrap soothed her. (May/83)

The idea that simple and repetitive activities can serve significant emotional needs was also brought out by the teacher of the emotional adjustment class. At the end of the first year, he shared tne following insight with other participants of this study:

> My guys would sit for two hours and play Dynatrack. [Note: Dynatrack is a program on the Terrapin utility disk which involves guiding a moving turtle around a circular track.] They would print out their score and they'd have this great score. Soon they thought "I'm great!". So if they wanted to take an hour and they were feeling bad, in a rotten mood or hadn't succeeded somewhere else, they could put in Dynatrack and use it. The first thing they always wanted to show people when they came in the room was Dynatrack. Dynatrack was something that they could be very successful at. (May 17/83)

There was also external confirmation that the students in the sites being studied were "different". Visitors to the various sites during the two year period always commented on how impressed they were with the confidence that many of the students exhibited. They expressed surprise at how easily many of the students related to strangers, how readily they would explain their particular activities, how easily they discussed their "bugs" in front of their peers and visitors, and how easy they found it to give "public" demonstrations of their work.

Although the focus to this point has been on the positive effect on students, it should be noted that many students experienced no change in their general confidence level, and four students actually reported a decline. Teachers found that students differed greatly in the way they approached computers:

> [Primary] Some are fearless and willing to try new things. Some stick to the same "safe" procedures over and over again. (May 15/83)
>
> [Junior] For most of the students it has a positive effect on self-esteem because they are working at a level they can handle and

> move on as they gain confidence. For others, it is simply creating the same thing each time and has become frustrating. They don't ask for computer time now. (Feb. 8/83)
>
> [Intermediate] I have noticed a problem. Some students rarely are the ones who accomplish a task or make a discovery first. The result is they rarely feel that peer buildup. I think that a teacher has to be aware of this and make sure that it is added to that student. The positive reinforcement is necessary to maintain the self-esteem in any teaching situation. (Dec. 15/83)

It was evident from the outset of the study that the teacher had a crucial and central role to play in assuring that the computer experience would be a positive one for as many students as possible. For example, one teacher felt quite strongly that:

> Any failure that is brought about in Logo is primarily the fault of the teacher and as a teacher I need to be very conscious that it is my expectations and my words that create the atmosphere. (Dec. 15/83)

However, the degree of sensitivity and the time required to attend to students' needs was often quite great. For example, teachers reported that:

> [Primary-Grade 1] Some little ones get easily frustrated; mainly over mechanics, such as, forgetting to space or hitting the RESET instead of the REPT button and the subsequent need to reboot. When successful, children get immediate gratification. (Dec. 3/82)
>
> [Junior] It was Mary's and Judy's turn. They find the computer difficult and frustrating. After 45 minutes on the computer, they asked if they could quit because they were afraid of getting behind in their work. ... they said they were tired of doing computer "work". ... I am not quite sure of how to handle this. (Sept. 27/82)
>
> [Intermediate] Today I spent time with two pairs of children who seem to have lost interest. They are bright kids and I didn't understand the growing lethargy. The problem was quite easy to find - a lack of success. The girls were measuring themselves by another group and in their private talks had decided that the lack of printed, correct and finished products meant that they were not very good. They began to hide. I had hoped that I hadn't created such a feeling! I talked to them and told them that what they were doing was very good. I feel that it is very important for the teacher to talk and spend time with the students at the computer. (Nov. 2/82)
>
> [Intermediate] The computer brings to the surface things that children often hide and the teacher overlooks, such as, lack of confidence. In a peer group these children

> float along. You have to come one on one on the computer and then it come to the surface. The idea that the computer is a very impersonal thing is very false. The computer itself is totally impersonal but what isn't is the child's reaction to it. The teacher must be there to deal with that. (Nov. 11/82)
>
> [Intermediate] I find it very important in the classroom use of Logo that I do not put expectations on students beyond the level of their understanding of the primitives being used. Some students desire to learn new primitives and to move into new directions without understanding. If I allow this to happen, sometimes self-esteem suffers. (Dec. 15/83)

Other evidence that the teacher played an important role in shaping the impact on students' general confidence came from an analysis of the factors in the learning-teaching environment among sites that had similar levels of positive impact on students. For example, in 1982-83, three groupings emerged (Figure 9.1). In Group A, 77% to 84% of the students reported an increase in their general confidence level, whereas such an increase was experienced by approximately 60% in Group B, and by only 37% or less in Group C.

In looking for an explanation that could account for the similarities between the sites within a group, and the differences among the three groups, no single factor pertaining to the students - such as location, class size, class profiles with respect to academic grades or students' perceived relative standing in the class, prior computer exposure, and the degree of confidence with which they approached the computer - could be found (Table 16).

The classes of sites 8a (Group A) and 10a (Group B) consisted of predominantly academically high achieving students, site 9a (Group C) consisted of an even balance between average and high achieving students with a few low achieving students; sites 6a (Group A), 7a (Group C), and 11a (Group B) were considered "typical" classes, with the bulk of the students being average, and a few high and a few low achieving students; and site 13a was a Learning Disability class. All students in all the sites had a chance to "touch" a computer before the study formally started. The students in site 11a used a word processor (Magic Window) and drill and practice software for approximately one to two weeks, and the students of site 8a had a few lessons on Logo before the project started.

Figure 9.1

Positive Increase in Junior and Intermediate Students' General Confidence Level during the School Year for Both One- and Two-Year Students

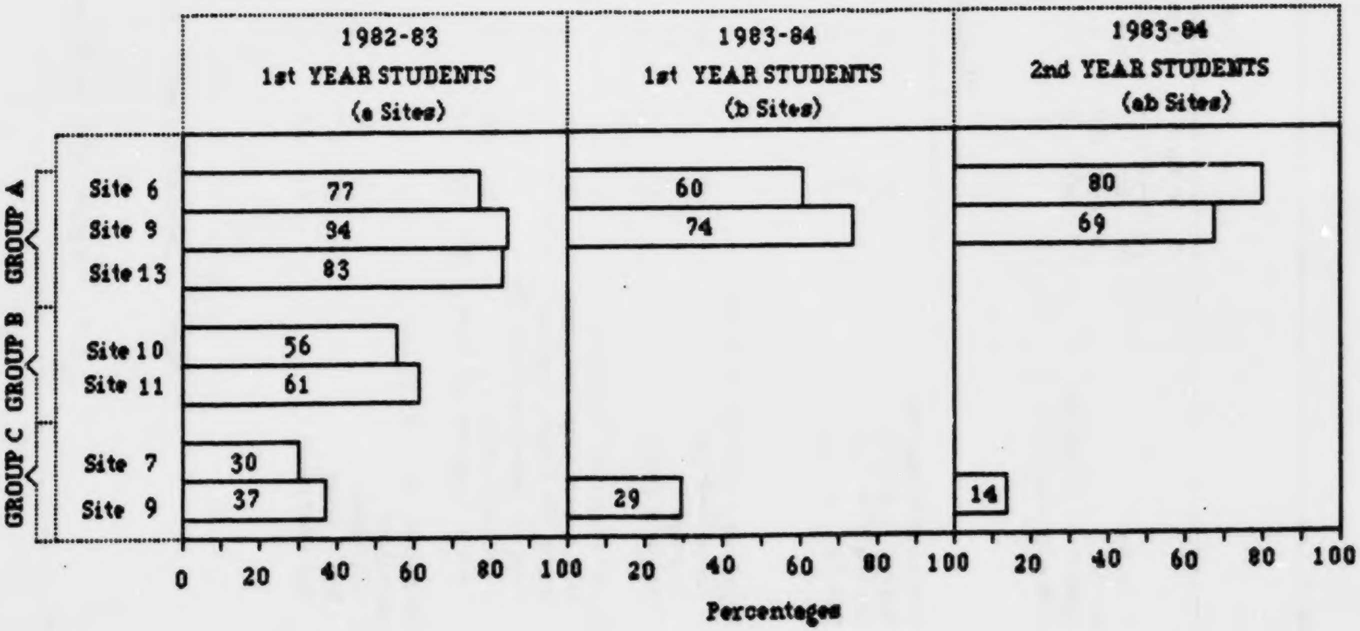


Table 16

Class Profiles of Students in the Study for their First Year

	1982-83							1983-84		
	* Group A			Group B		Group C				
Site No.	6a	8a	13a	10a	11a	7a	9a	6b	8b	9b
Grade	5	6/7	SLD	8	8	5	7/8	5/6	7	8
Number of Students	27	26	6	16	32	27	32	20	16	18
Computer Access	C	C	C	L	C	L	C	C	C	C
	(Numbers in Percentages)									
Academic Standing:										
Mostly A or A/B	-	84	-	94	30	-	48	-	33	24
Mostly B or B/C	-	16	-	6	57	-	42	-	67	47
Mostly C or less	-	0	-	0	13	-	10	-	0	29
Relative Standing in class:										
Above average	-	36	-	38	35	-	41	35	22	24
Average	-	52	-	62	65	-	49	65	64	76
Below Average	-	12	-	0	0	-	11	0	14	0
Prior Computer Exposure:										
Wrote 1-10 Logo programs	-	96	50	13	83	-	56	20	13	29
Wrote 10+ Logo programs	-	0	0	6	10	-	0	0	0	29
Read at least one article on computers	-	62	100	38	74	-	56	40	86	76
Have a computer at home	20	15	17	12	0	6	3	25	20	29
Perceived ability to use computers:										
Confident	-	24	75	62	87	-	72	95	80	65
Don't know	-	52	0	38	13	-	10	0	7	11
Not Confident	-	24	25	0	0	-	17	5	13	24

Note: Computer Access: C - classroom
L - laboratory

* Groups refer to those in Table 1.

Just as no single factor pertaining to characteristics of the class could be found that would explain the different changes in the students' general confidence level, neither could any single factor pertaining to the characteristics of the teachers be identified. All of the teachers were considered to be very competent professionals and all of them had ten or more years of teaching experience. The teachers at sites 8a, 9a and 11a had prior experience with BASIC and had given computer workshops to teachers and students in that language. The teachers at sites 8a, 9a and 10a had had a short introductory course on Logo, and the teachers at site 6a and 7a had had a one-day workshop before the project started.

The teachers of the three Group A sites managed to make the cognitive and social activities on the computers an integral part of their classroom activities and to make the computers available to their students whenever the students were in their homeroom, regardless of what else was being taught at the time (except for mathematics in site 6a). Although they occasionally were prepared to repeat a lesson for individuals, they generally encouraged students to get the necessary information from other students. They used turtle geometry exclusively for three months but then extended Logo to include text and introduced the Bank Street Writer for word processing and occasionally other educational software for exploration. The teachers also encouraged the sharing of discoveries and problems among students, and set aside time for class demonstrations and discussions. They offered some structured activities - especially at the outset - as well as some "computer challenges" but the students were usually free to do them or to explore on their own. The teachers spent many hours learning about the hardware and the language, and thinking about, and experimenting with, different ways of utilizing the computers in their classroom.

Sites 10a and 11a (Group B) used a computer-room. The students of site 10a went to a computer room outside their school for a three-hour period once a week and were taught by someone who was not their regular classroom teacher, although the regular classroom teacher did come with the class and acted as an observer. The students of site 11a went to a computer room within their school for a 40-minute period every day and were being taught by their regular teacher. Both teachers were enthusiastic about Logo, but their teaching styles were quite different. The teacher from site 10a strongly resisted giving directions and only did so when the students insisted on it. He preferred to encourage students to explore a great deal with one idea or concept and to respond to individual questions. He usually had one to two people that he could call on for assistance when he did not know a technical or programming question, or when there were too many questions all at once. The teacher from site 11a had no assistance and felt it necessary to give formal lessons and assigned tasks - which was also his preferred teaching style - in order to keep the computer experience manageable and positive for both him and his students. However, he did allow some free explorations within those parameters. Both teachers allowed informal group interaction but did not set aside time for class discussions and sharing (the teacher from site 10a expressed regret at not having done so). Neither engaged their students in computer or computer-related activities outside their actual time in the computer laboratory. The teacher of site 11a used Logo, as well as programmed instruction software such as Milliken Math, as an extension of the mathematics curriculum. He also used Magic Window for word processing and other software for language development, and taught his students some BASIC. The students from site 10a spent most of their time exploring turtle geometry and did not explore the word and list capability of Logo until their fifteenth session, i.e., after 35 hours on Logo. They were allowed to "play" with some educational games during their last session. The regular classroom teacher did not attempt to make any connections between turtle geometry and the standard school curriculum. Although the settings and conditions of sites 10a and 11a were quite different, the overall impact on the students' general confidence level was nearly the same, but still lower than those in sites 6a and 8a.

In Group C, site 7a had access to a computer room and site 9a had one computer in the classroom. The teachers of both of these sites had great difficulty in tying the computer activities to the regular academic program and in finding a suitable arrangement for accessing the computer(s), but for very different reasons. The teacher's area of expertise in site 7a was in language/arts and science but not mathematics. He found it very difficult to relate to Logo, and to see the benefits of it, especially since another teacher taught mathematics to his class. A few months into the study, he stopped using Logo altogether, although he continued to use the computers (but not on a regular basis) for word processing and for some drill and practice exercises. He also found it very difficult to find an effective way of giving students free reign to explore Logo since he was overwhelmed by the number of questions at the outset. Since his time had to be divided between attending to those students who were on the computer and those who were engaged in other activities while awaiting their turn on the computer, he found that the computer room experience became frustrating for both himself and his students. On the other hand, the teacher of site 9a considered mathematics as one of his areas of expertise. He had taught BASIC before and knew FORTRAN and assembly language. However, he knew Logo only at an "introductory" level and did not feel comfortable turning the situation into a shared learning experience. He felt unable to generate activities and ideas that could ignite and/or keep his students' interest. He also found it difficult to find a suitable schedule for accessing the computer because his students were on a rotary system (students left the classroom for specific subjects which were taught by a specialist teacher) for part of the day. He attempted to schedule the computer while regular classes were being conducted but he felt ill at ease when students missed a lesson. He found it difficult to find the time to repeat a lesson for a few students and he was not willing to give up regular class-time to explore and discuss strategies so that students would become more self-sufficient. He did attempt to give students access to the computer during lunch hours, after school, and some evenings, but that too began to interfere with other demands on his time.

The overall effect on students who were new to the study in the second year was generally lower by 8% to 17% than that on students during the first year (Figure 9.1). One possible reason could have been that all three teachers did not take as active a part in teaching Logo during the second year and relied quite strongly on the second year students to act as teachers to the new students. Also, because of various constraints the number of sharing sessions and class discussions in sites 6(b,ab) and 8(b,ab) were greatly reduced during the second year. In addition, the students in site 8(b,ab) had four different computers: a COMMODORE 64, an ATARI 800, an APPLE II+ and an APPLE IIe in the classroom during the second year. This created such strong preferences among students that some actually refused to take their turn at the computer if it meant working at a machine with which they were not familiar or which they disliked - possibly because "computer-time" was optional and the teacher did not have time to teach about the special features of the different machines nor about the different Logo versions. In addition, the manuals were only readily available to a few boys who were "in charge", creating problems since students were not as eager to share their knowledge during the second year as they had been during the first. Such lack of co-operation was particularly pronounced between boys and girls, i.e., boys refused to help girls and sometimes actively interfered with the girls' computer time. (For further details see Chapter 10, 'Differential Effect on Male and Female Students'). An additional difference in site 6(b,ab) was that the class was a Grade 5/6 split. Whereas, students in both grade levels in the split grades that were in the study during the first year (sites 8a and 9a), started at the same level of competency (ignorance), and hence were treated equally with respect to all computer activities, the older students of site 6(b,ab), who already had one year of computer experience, requested from their teacher special opportunities in order to give them a sense of "being in a higher grade". They were consequently asked to assist in setting up a computer booth for the school's Grade 6 subject fair and to do some background research on computers for it. They also participated in an extensive exchange with a class of slow learners from another school. Visits were exchanged, which culminated in the Grade 6 students teaching Logo to the slow learners. They were awarded special certificates of merit for these events by the school. The Grade 5 students during this time had library studies and no special computer activities were arranged for them.

This differential treatment of the two groups, rather than age alone, most likely accounted for the 20% difference during the second year between new (site 6b) and continuing (site 6ab) students with respect to the general impact on their overall confidence level (Figure 9.1). No clear relationship between age and the impact on the general confidence level could be found in the two split-grade classes during the first year: 81% of the younger students in site 8a recorded an increase in general confidence level whereas 90% of the older ones recorded an increase. Analysis of these results with respect to the gender of the students, however, revealed that 100% of the boys in both Grades 6 and 7 (within the same class) received an increase in their overall confidence level, whereas only 80% and 70% respectively, of the girls reported an increase in general confidence level (Table 17). In site 9a a different pattern emerged: 43% of the older boys as compared to 14% of the younger boys reported an increase, and 71% of the younger girls as compared to 22% of the older girls reported increase in general confidence level.

Among the students who had been in the study for two years, 80% and 69% in sites 6(ab) and 8(ab), respectively, still indicated a positive impact on their general confidence level during the second year. However, only 14% of the students in site 9ab still recorded a positive impact (Figure 9.1). Several of the continuing students in all three sites began to feel the lack of teacher input towards the end of the year and began to complain that they weren't learning anything new about Logo or other software. The students of site 6ab still had other external and social rewards, but those of site 8ab and 9ab did not. This may account for why 80% of students in site 6ab still recorded an increase in general confidence level at the end of the second year, and fewer students did so in the other two sites.

In summary, the key factors, under the control of the teacher, that had an impact on students' general confidence level were determined by:

1) the degree to which teachers managed to integrate the activities on the computer(s) with their regular classroom activities;
2) the degree to which they managed to balance direction with free exploration;
3) the degree to which they responded to the needs of their pupils;
4) the degree to which they encouraged individual students to share new discoveries and problems with the whole class, or beyond;
5) the degree to which they reduced competition or preferential treatment among individuals; and
6) the manner in which access to the computers was arranged.

Table 17

Analysis of Responses Regarding General Self Confidence for Students in the Study for the First Year in Sites that had Mixed Age Groupings

Site No.		6a	6b	8a		8b	9a		9b
Year of Study		1982/83	1983/84	1982/83		1983/84	1982/83		1983/84
Grade level		5	5/6	6/7		7	7/8		8
Subgroup Analyzed		5	5*	6	7	7*	7	8	8*
Number of Students									
	Boys	15	12	6	5	10	7	7	8
	Girls	11	8	10	5	5	7	9	9
	Combined	26	20	16	10	15	14	16	17
		(Numbers in percentages)							
++:	Boys	53	8	33	20	40	0	0	12
	Girls	36	50	10	20	0	0	0	0
	Combined	46	25	20	20	27	0	0	6
+:	Boys	27	42	67	80	40	14	43	26
	Girls	36	25	60	60	60	71	22	22
	Combined	31	35	62	70	47	43	31	24
0:	Boys	7	33	0	0	10	86	43	50
	Girls	18	12	20	20	40	15	78	78
	Combined	11	25	12	10	20	50	63	64
-:	Boys	7	0	0	0	0	0	0	0
	Girls	0	12	10	0	0	0	0	0
	Combined	4	6	6	0	0	0	0	0
NA:	Boys	6	17	0	0	10	0	14	12
	Girls	10	0	0	0	0	14	0	0
	Combined	8	10	0	0	6	7	6	6

Note: *Does not include students in the class who have been with the study for two years.

++ I feel much more confident about my abilities in general
+ I feel more confident about my abilities in general
0 No change
- I feel less confident about my abilities in general

10. DIFFERENTIAL EFFECTS ON MALE AND FEMALE STUDENTS

Throughout the first year of the study, there were no obvious indications of differences in the use of the computer by boys and girls, based on either observations in the classroom or interviews with the teachers. All of the students appeared to enjoy their time at the computers. At the end of the first year, students were given a quiz on the turtle geometry component of Logo. The results of this quiz gave the first indication that there may be some important differences between the experiences of the boys and girls.

THE LOGO QUIZ

At the end of the first year, the quiz for the primary students focused primarily on the estimation of distance, left and right turns, and shape recognition. There were no obvious differences in the performance of these tasks between the boys and girls. The junior and intermediate students were given more challenging questions and on these, the boys tended to perform better than the girls. There were, however, large variations in performance of students among the various sites which were primarily a function of a teacher's teaching style and the amount of time students spent with Logo. (Copies of the quiz may be found in Figures 18.1 and 18.2 in Chapter 18). The largest difference between the performance of the boys and girls was seen in a Grade 6/7 split class (site 8a), where the students had spent the most time working with Logo (Figure 10.1). The boys' scores (n = 10) ranged from 50% to 86% with an average score of 71% compared with the girls' (n = 14) average score of 53% ranging from a low of 36% to a high of 70%.

At the end of the second year, the junior/intermediate level quiz from the previous year was given to all students. Again, the largest differences in scores between boys and girls occurred at site 8(b,ab) (Figure 10.1). However, during the second year, behavioural differences were also observed at this site. The scores of students in the study for one year were lower in the second year than those in the first year but still the boys (n = 9) scored better than the girls (n = 5), with a high score of 68% and a low of 27% compared with 58% and 16% for the girls. The differences in averages between the boys and girls was 14% in favour of the boys. The students in the study for two years all scored higher: the boys (n = 4) all scoring between 70% and 80% and the girls (n = 8) between 34% and 92%. Again, the difference in averages was 13% in favour of the boys (Figure 10.1). The difference between these scores would have been even greater if the boys had taken greater care in recording formatting details of procedures. All of the continuing boys in the second year had lower scores than the previous year, with an overall average of 75% compared to 81% the previous year. Several of the girls increased their scores in the second year, bringing their average score to 62% compared to 50% the previous year. Among all the sites, the only group of girls to perform better than the boys in their class were the students who had been in the study for two years at site 6ab (Figure 10.2).

The questions on the Logo quiz for which the performance of the boys was consistently better than the girls, required writing procedures to draw specific shapes or to visualize and sketch what the turtle would do, given certain instructions. Whereas, most students knew the number of 'repeats' necessary to complete the shapes, the boys were much more likely than the girls to know the size of the angle needed. Boys were also more proficient at questions relating to the concept of a variable.

Figure 10.1

Logo Quiz Results for Boys and Girls in the Study

for One and Two Years at Site 8

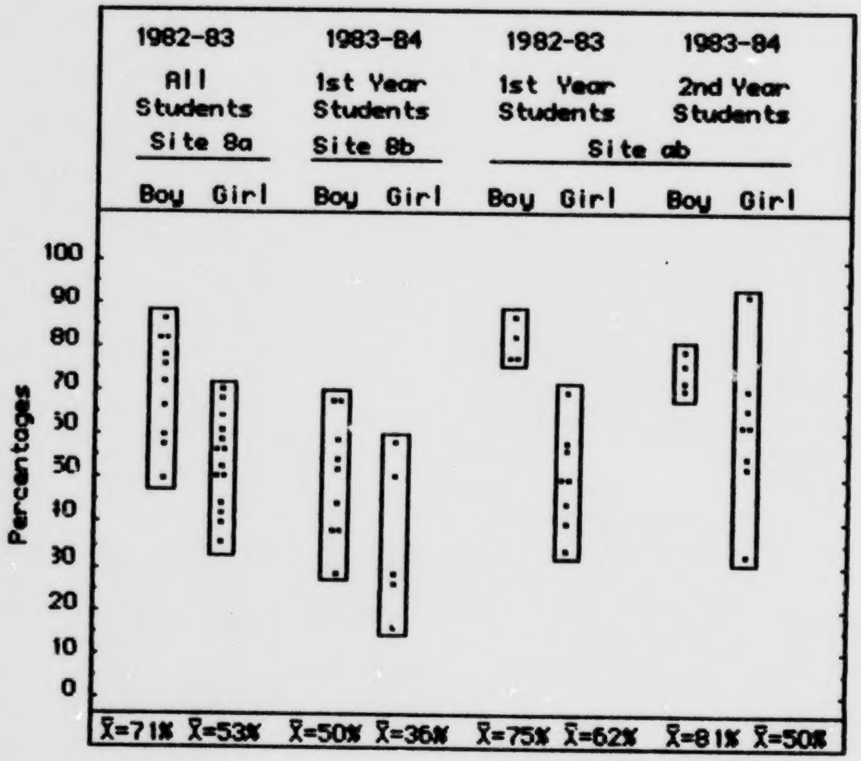
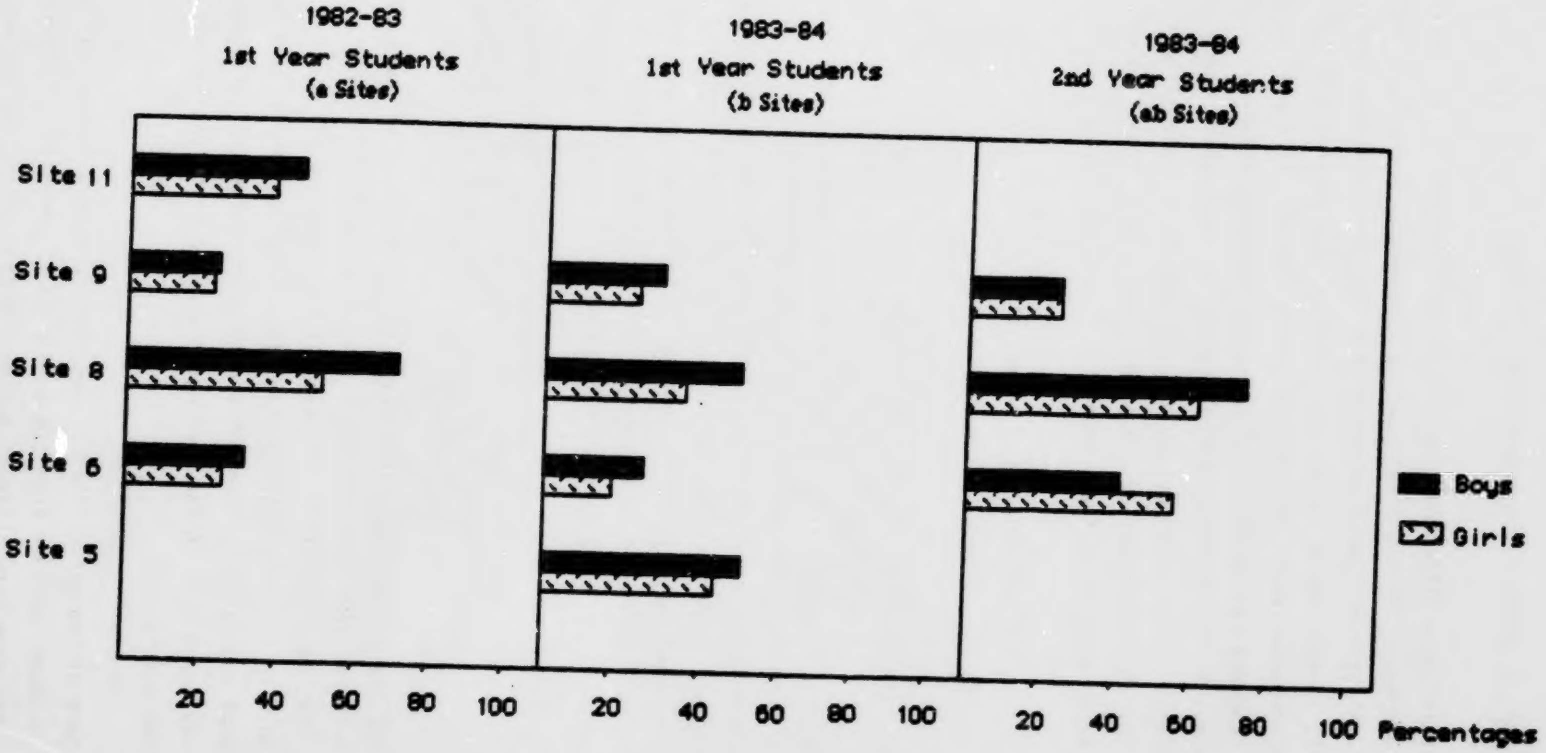


Figure 10.2

Average Scores for Boys and Girls on the Logo Quiz Given to Junior- and Intermediate- Level Students at the End of each Year



1982-83
1st Year Students
(a Sites)

1983-84
1st Year Students
(b Sites)

1983-84
2nd Year Students
(ab Sites)

NATURE OF THE STUDENTS' COMPUTER WORK IN CLASS

To explain these differences at site 8, an analysis of the contents of all of the students' disks was made. In the first year of the study, it was not possible to identify an individual student's work as there were two, and sometimes four, students sharing a disk. However, in most cases, it was possible to make general comparisons since the students working together were, according to their teacher, of equal academic ability. In the second year, students had their own disks, but since they worked with partners it was again impossible to follow individual students. In both years there was a single boy/girl partnership. Such mixed gender data was omitted in compiling a content analysis of students' disks for the first year of the study (Table 18). From this content analysis, two main differences were identified, namely:

1) the amount of work saved; and
2) the variety in the work saved.

Similar results were also seen during the second year.

1) Amount of Work Saved: Without exception, the boys had saved more programs than the girls. Several of them had used more than one disk whereas, at the other extreme, one pair of girls had only seven files on their disk, including several utility files given to them by the teacher. Some work may have been erased from the disks but no corroborating evidence could be found for this from checking through printouts and log books. However, when the girls were interviewed at the end of the second year, some evidence emerged which may explain why girls did not have more work saved on their disks. One girl commented:

> If you are working on the computer and the boys walk past they will make fun of your work, as if it is so poor that nobody would do it, so you just erase it. (May 1984)

2) Variety of the Work: Not only was the quantity of the work done by the boys greater, but there was also more variety. The girls tended to stay with the ideas they knew and with which they were familiar. For example, one pair of girls spent most of the first year working with circles, filling them with different colours and combining them to make lollipops and balloons. In the second year, these two girls worked with different partners but they spent most of the year again working with circles and repeating some of their previous year's work.

Many of the girls liked to use Logo to draw pictures. Leigh and Lorna steadily worked on a 'Snowman' picture from the beginning of December until February, improving it bit by bit. They were very thorough and methodical, aiming for perfection. According to the teacher, this was typical of the girls' style of working with Logo. The boys were much more innovative and liked to experiment with new things. They explored many more Logo primitives. The boys were eager to make their own games and discovered a variety of ways of creating movement on the screen. They frequently combined text and graphics for their games. Many of the boys were also familiar with BASIC, having learned it on their computers at home; this gave them ideas for working in Logo as they tried to do similar things. The boys also enjoyed completing the challenges given by the teacher, whereas only a few of the girls did. As one girl wrote:

> Wendy and I often sit back there at the computer with nothing to do. We try the teacher's challenges but they are so boring with just squares, triangles, rectangles etc. We like colours and arcs. I'd like it if we did more pictures. (Jan. 84)

During the second year, the teacher began to notice differences between the work of the boys and girls and wrote in his log book:

> Girls appear to be more consistent, following a pattern more carefully, completing programs with precision. They tend to work on a program longer, anticipate its end and see it through. The boys however often jump from idea to idea; their learning is quick, not solid. Girls tend to stay away from the problems that involve a degree of conditional statements. Where there seems to be a mathematical concept involved, many of the girls back away. (Dec. 1983.)

There was little difference in the amount and type of work done by either Grade 6 or Grade 7 boys in this split 6/7 class in the first year and by the experienced and inexperienced boys in the second year of this study. However, for the girls, the amount and complexity of the work increased with age and ability (Table 18).

Table 18

The Contents of the Students' Disks at Site 8a

	BOYS				GIRLS				
	7A+	7A+	6A+/A	6A-	7A+	6A+	6A	6A-	6A-
Repeats	x	x	x	x	x	x	x	x	x
Piegragh	x	x	x	x	x	x			x
Variation of piegraph			x	x		x			x
Letters/nos.	x		v	v	x	x	v	x	x
Design with letters						x			
Nametags	x	x	x	x	x	x	x		x
Invitations	x	x	x	x		x		x	
Variables	x	x	x	x	x	x	x	x[1]	x[2]
RANDOM	x	x	x	x				x	
SETPOS	x	x	x	x	x	x		x	x
Recursion	x	x	x	x	x		x		
Checkerboard	x		x	x	x	x			
Checkerboard variation						x			
Combining many Procedures	x	x	x	x	x				
Words/lists	x	x	x	x	x			x	
SLIDE	x		x	x					
3D-Drawing	x	x	x	x			x		
Movement	x	x	x	x					
Games	x	x	x	x	x				
Use of math. component	x	x	x	x	x				
Combining graphics/text	x	x	x	x					
READCHAR	x	x	x						
Startup File	x		x						

v use of variables in drawing letters

1 only variable used identical to the one on 7A+Girl disk

2 doesn't appear to understand variables.

A+ above average student; A average; A- below average

ACCESS TO COMPUTERS AT SCHOOL

One of the key factors that generated these differences in the performance between boys and girls appeared to be access to computers. From the questionnaire given at the beginning of the first year, it was clear that all the students in the class of site 8a had similar computer experiences prior to the beginning of the study. They all had equal time scheduled on the computer during regular school hours: 20 minutes per day on five days of a six day cycle. There was no record of who used the "extra time" during lunch hours and before and after school. These periods were available to anyone who wanted additional time on a computer. Definite differences between boys and girls emerged in the use of this "extra time". The teacher reported that:

> Boys are very aggressive at getting time booked after school. They are there at 8:15 a.m. waiting for me so that they can sign up. Girls aren't. Half way through the morning they will ask if the computer is available at recess. Often it is too late then. (June/83)

It was likely, therefore, that the boys took over the free periods and that the girls did not want to compete with them.

During the second year of the study, there were three periods in each 6-day cycle when the computers were not assigned to any particular group. Again, the boys were much more aggressive with respect to the use of these free periods. This problem was brought to the teacher's attention by the girls and discussed by the class in October, but the teacher insisted that he did not wish to schedule "free periods" on an equal rotation basis. The signing up for these period was to remain on a strictly first-come first-served basis.

During the second year, differences in the way boys and girls of site 8 used their scheduled computer time emerged. Factors that were not operating during the first year began to have a differential impact on boys and girls. Although each students had been assigned 30 minutes per day on a computer, the use of that time became voluntary and, at times, access was withdrawn from particular students because of unfinished school work. The demands of the regular curriculum had become greater, and with the rotary system, students were in the classroom for only half of the school day. In addition, the number of computers in this site was increased from two to five: however, there were three different models among them. These factors created tensions within students between "regular" school work and the desire to work with computers. It seemed as if girls felt this tension more strongly, as the following comments by two girls indicated:

> I haven't been on the computer for a long time because I have been doing classwork. It is near the end of the year and test time and report card time. I don't want to get a zero. (May/84)
> The boys don't seem to be worried about these things though. They don't care. (May/84)

The three computer models also created preferences, especially since the teacher did not take time to familiarize his students with the new models. Most students, therefore, preferred to work with the APPLE II+ computers which they had had the previous year. This introduced a new element of competition for accessing computers, the nature of which was described by a girl in the following manner:

> Even though we have a schedule for the Commodore and the Atari, the boys will kick you off the Apples when it's your turn. They'll pressure you to trade with them. If they get to the computer first, they'll say "oh, I thought you said I could trade with you". They don't listen to you, they just push you off to the other computers. (May/84)

Separate interviews with the boys and girls of this class, at the end of the second year, revealed that each group agreed that girls had had less time on the computers. Boys however, gave startingly different reasons for this condition than the girls did. The boys gave the following reasons:

> At the beginning of the year the girls were always complaining that they didn't get any computer time because the boys were always on the computers. They would sit in their chairs and watch the boys go back to the computers and then complain. I didn't find too many of them really wanted to go on the computer at all. None of them rushed for it like we used to. (May/84)

> The girls had equal opportunity but they didn't take it. Some of them just never wanted to go on, so we got the computers two or three times a day. We'd follow the schedule and we'd see a free computer ten minutes after the scheduled starting time, so we'd ask if we could use it. (May/84)

> They [the girls] would complain that we had taken their computer time, but they didn't want to go on in the first place. (May/84)

The girls saw the situation quite differently:

> The boys hog the computers. If we go back and say we are on now, they will say they are on and won't move. The teacher says to settle the argument among ourselves but the boys still won't move and we will be told to sit down because we are causing a disturbance. (May/84)

> Sometimes you go back and its your computer time and the boys will say the teacher said they could stay on and they will let you have their computer time tomorrow, but when tomorrow comes they won't let you. (May/84)

> The boys don't stop at the end of their time. They'll start printing out and that can take ten minutes of your time. (May/84)

> If the boys want to get you off the computer they'll turn the machine off. (May/84)
>
> The boys get more time than the girls. If there is a free period and you're trying to get on they'll push you off. (May/84)

The teacher was quite aware of these problems early in the year but he did not have time to deal with them. He had written in his log book:

> Girls have been found to have few printouts, I started checking the reason. I found that the boys in their own way had relegated the girls to machines without printers and, in particular, non Apples. (Oct./83)
>
> The girls in a grade seven class are often considerably more mature than the boys. In fact they sometimes make excuses for reasons why they shouldn't use the computer or shouldn't be on the keyboard at a certain time, only to accommodate the immaturity of the boy who is on the machine. The other day, a girl in the class was working with a boy and I noticed that although the ideas seemed to come from her it was the boy who was actively pounding the keyboard. There were a lot of mistakes, a lot of problems, and she was trying to be gentle. I took her aside and asked her why she didn't take a turn on the keyboard. Her answer floored me. She said 'He needs to feel he is in control'. (Dec./84)

Competition between boys and girls in this class was further aggravated by a class rule that no disks were to be left lying by the computer. Any disk that was found would be locked away for three days and the owner of that disk was not allowed to use the computer during that time. According to the girls:

> If the boys find a boy's disk lying around they'll say "Oh, I'll be nice and put it away for him". With the girl's disks they don't say that. They tell the teacher and the disks get locked up for three days. That's another way the boys get more time. (May/84)

One girl even went farther and said:

> The boys take the girls disks out and then tell the teacher they found them left out and so we have them locked up for three days. (May/84)

ACCESS TO COMPUTERS AT HOME

The boys at site 8 not only had the advantage of extra computer time at school, but were much more likely than the girls to have a computer at home. By May 1984, every boy in this class who had been in the project for two years had a computer at home (Figure 10.3). In general, boys were much more likely than girls to have a computer at home. Only the girls in site 6 who were involved in the project for two years, and the first year girls at sites 5 and 9 had a higher percentage of home computers than the boys. The girls in the study for two years at site 6 were also the only group of girls to perform better on the Logo quiz than the boys (Figure 10.1).

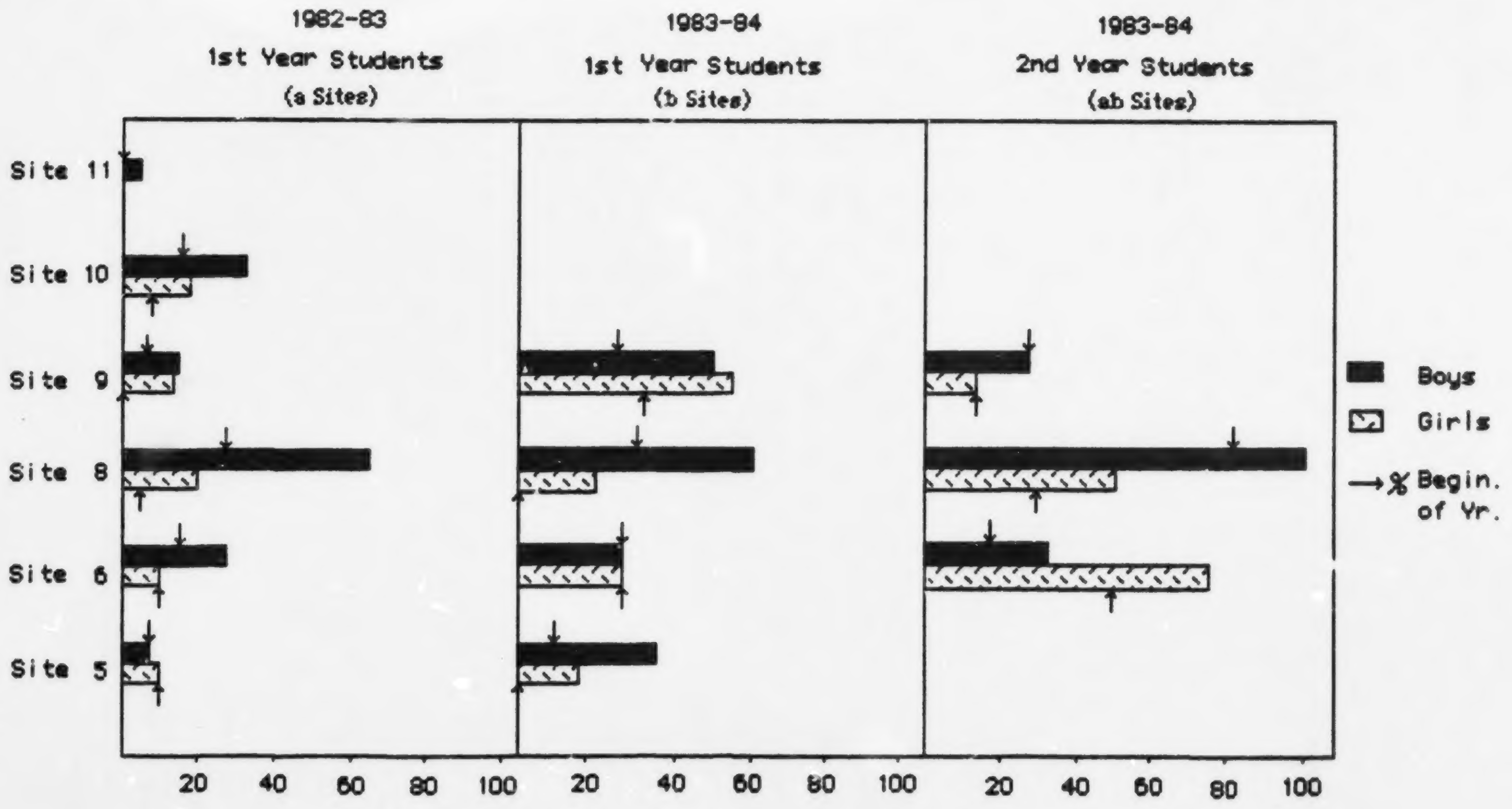
At the end of the second year of this study, the girls at site 8 felt that they were so far behind the boys that they could never catch up. This was not, they stressed, because they were not as good as the boys. They were all very confident that they could do as well as the boys if they had equal access to computers both at school and at home. Girls often didn't bother to attempt challenges set by their teacher because, as one girl said, "Why try the challenges when the boys can do them at home?"

Although the girls perceived this access to home computers to be a problem, in fact few of the boys were able to work in Logo at home. Most of the home computers used by the boys (five VIC 20's, two TEXAS INSTRUMENT 99's, one ATARI 400, two ATARI 2600's and two APPLE IIe's) did not have Logo capabilities. The boys generally worked in BASIC at home and the previous year the teacher had given classes in BASIC after school at the request of the parents of these students. Six of the girls mentioned they had computers at home: three TEXAS INSTRUMENT 99's, two COMMODORE 64's and an ATARI 800. Although three of the girls had computers similar to those used in the classroom (COMMODORE 64 and ATARI 800), a common complaint from the girls was that they did not know how to use the COMMODORE or the ATARI computers. They frequently would skip their computer time when assigned to either of those computers. It could not be determined from the data collected whether the computers at home were intended for (male?) siblings, and why the girls did not learn about these machines at home; or, if they did learn at home, why they did not share their knowledge with the other girls. Although none of the boys had either a COMMODORE 64 or an ATARI 800 computer at home, most of them learned how to use them in the classroom.

The girls also mistakenly believed that the boys spent "all their waking hours" on their computers at home. But according to the questionnaire given to the students at the end of the year, there was little difference between the amount of time spent on the computers at home by the boys and girls. Of the boys who were in the study for two years, two said they spent between 15 and 30 hours a week on the computer at home and the rest said between 2 and 15 hours a week. The "new" boys spent less time: one said between 15 and 30 hours, two said 2 to 15 hours and the rest less than 2 hours. All the girls with home computers said they spent between 2 and 15 hours a week working on them.

Figure 10.3

The Percentage of Boys and Girls With Home Computers at the Beginning and End of Each Year



Since more of the boys of site 8 had computers at home, they were also more likely to have access to manuals and books. During the first year of the project, the teacher had kept all school manuals locked away so that the students could not use them. In the second year, possibly because the teacher was frequently absent, he gave the key to the cupboard in which the manuals were kept to one of the boys. Since there was no sharing between the boys and girls, this gave the boys another advantage. As two girls said:

> The boys have manuals. Last year the teacher wouldn't let anyone use the manuals, but this year the boys use them all the time. They own them. They have the key to the teacher's cupboard. (May/84)
>
> That's why the boys have better programs than the girls. (May/84)

DIFFERENCES IN ATTITUDES

At the end of each year, the students were asked if there was anything they disliked about having the computers in the classroom. The differences in responses between boys and girls were again quite pronounced in site 8. Frequently, the girls mentioned that they did not like missing classes as it meant extra homework, or that they were afraid of falling behind in their regular schoolwork since that would adversely affect their grades. The teacher noticed this difference early in the second year:

> I am convinced that the boys and girls work equally hard but I do see a difference in their nature. When hassled and pressured the girls tend to bow to the pressure, whether it be the volleyball coach or history teacher, but the boys continually choose computers over the pressure and just accept the punishment of the teacher concerned. (Dec./83)

Near the end of the year, he reported that:

> Some of the girls have opted out recently to get their other school subjects done. Connie and Janice are the exceptions. They have used the computer regularly, but they use it as a relief from classwork. They are very low students. (May/84)

Some of the boys did mention that they would prefer to go to a computer room, especially since they were beginning to feel the pressure from the classroom teacher towards the end of the year.

> When we go to the computer we miss work and if we don't get it done Mr. O gets mad at us. It would be better if we had a computer room class. (May/84)

In the first year of the study, the teacher had taught all the core subjects so the students were in the room for much longer periods and there was more flexibility. In the second year, during a 40-minute class period, a student was required to come in, prepare his class lesson, show his homework, go to the computer, plan his work, make a hard copy, save his work, get back to the lesson, pick up his assignment and leave. This created a hectic period and some students chose to miss their computer time or at least to delay going on the computer.

Not only were there differences between boys and girls in the amount of time spent at the computer but also in how that time was spent. The boys in site 8(a,b,ab) were a lot more competitive than the girls. The teacher presented weekly challenges to motivate the students at the computer. The challenges were designed to encourage students to think and discover new things for themselves as no books and manuals were available. The challenge for one week in October, for example, was "Can you make three figures, each having a common side. Each figure should have one more side than the previous one". In the second year, there were two challenges each week, one for the "old" and one for the "new" students. The challenges were optional and students were free to work on activities of their own choice. The boys really enjoyed working on such challenges. Those who finished the challenges first were rewarded with an APPLE sticker or a book cover and a lot of praise from the teacher and from peers. While the challenges were a great incentive for the boys, who "always got the challenges done first", many of the girls began to feel left out. Many also stopped doing the challenges because their efforts were not acknowledged and recognized:

> Boys get commended for things that a girl can also do but they complete it half an hour later and it doesn't matter then. (May/84)
>
> If you don't have a chance to be commended why bother doing it? (May/84)

The teacher was aware of the importance of positive feedback for work done when he recorded in his log book:

> I have noticed that some rarely are the ones to accomplish a task or make the discovery first. The result is they rarely feel that peer build up. (Dec./83)

However, he was not sure how to rectify this problem. The many demands on him, both in and out of the classroom, did not allow him to spend time on such creative problem solving.

Since many of the girls did not like to attempt the challenges, they often complained that they didn't have anything to do. During the first year of the study, the classroom environment was very different: the teacher was better able to observe students at the computers and to set aside some time for instructions, class discussions, and the sharing of discoveries. There was little time for this in the second year, and the teacher felt quite frustrated:

> I have discovered a change in the past year. Last year I often talked to groups of students about similar kinds of problems. We talked openly about correction, direction, and discussed new primitives. This was part of a core class that I had over a period of hours every day. This year on a rotation basis I

> don't have that time. I find that group activity is quite limited, that lessons must be taught in a given space of time and that the back of the room (the computers) often is almost without my involvement. (Dec./83)

The teacher did attempt to set aside a period for computer instructions or discussions once a week; however, since it wasn't an official part of the curriculum, this period was frequently needed for other subjects. The girls seemed to miss these lessons and discussion periods most strongly. Several girls commented that:

> We had a special period each week designated for computers but we didn't use it for that. We always have to do other work; usually spelling or grammar. (May/84)
>
> We would like to learn new things on the computer during that time. (May/84)
>
> It was much more fun last year because we were always learning new stuff. (May/84)
>
> I really don't think I've learned anything this year. (May/84)

The difference in knowledge between the boys and girls was accentuated because there was no sharing between them. The "inexperienced" boys in the second year became absorbed in the computer culture of the "experienced" boys, and they quickly caught up. As the boys made new discoveries they shared them amongst themselves. The girls did not create such a computer culture. They were left behind and became increasingly disenchanted. As one girl commented:

> With the challenges, he (the teacher) keeps increasing the difficulty but it just leaves us farther behind. The challenges are always geared to the top boys but he doesn't teach you how to do it. Nobody shows us, so we don't know how to do it. (May/84)

SEX ROLES IN THE CLASSROOM

There were very few boy-girl pairings among all the grades studied. Even when a boy and a girl were partners they frequently split their time at the computer. Some reasons for this were gleaned from remarks made by students from sites 6 (see Chapter 8) and 8. The girls from site 8 gave the following reasons for not wanting to work with boys:

> I partnered a boy for awhile and hardly got to do anything. I touched the keyboard maybe twice in two months. (May/84)
>
> I also worked with a boy for awhile and we always had to do boy stuff. (May/84)
>
> If you go on with a boy they will usually ignore you totally. If you say anything, they say "you've got to be crazy". (May/84)

One boy commented:

> When we had girl/boy computer partners some of us boys used to hog it from the girls. (May/84)

In site 8, the boys were also much more willing to volunteer to do things on the computer for the teacher. For example, in November, the teacher asked for volunteers to make a demonstration disk for a conference: only boys volunteered. He picked three boys and asked a girl to help. The boys, however, without consulting the girl, decided to work at the home of one of the boys, thus excluding the girl from working on the task. At the end of the year, the girls complained that they were never asked to do special jobs, like making disks; it was always the boys.

The addition of a COMMODORE 64 and an ATARI 800 to the class of site 8(b,ab) during the second year of the study generated new "experts" among the boys, even though two of the girls had such models at home. The girls told the researcher that the boys were the only students who knew how to use these computers. The boys were expected to show everyone in the class how to use them since the teacher did not have the time. The boys shared their knowledge with other boys but they appeared reluctant to help the girls as the following comments (made by girls) showed:

> If you are on the Commodore and you don't know how to use it the teacher will always tell you to ask someone. You have to ask the boys because they are the only ones who know how to use it, but they will never help you. They'll just come and take over, so there is no point in going to the computer in the first place. (May/84)
>
> If you ask one of the boys for help at the computer they'll just say "oh, you girls are so smart you can figure it out for yourselves". (May/84)
>
> Steven was our teacher. He wouldn't show us anything. He would just come back and type it all in for us so we didn't learn a thing. (May/84)

The boys would frequently bring games from home to play at recess and lunch time but when the girls asked to use them they were told by the boys "girls can't play games". When the girls were asked if the boys reacted like this in other subjects the girls said:

> Yes, math. They like to show off. They think they are better than anyone else. (May/84)
>
> Yes in soccer. They won't even let us play because they think they are too good for us. They say they want a more challenging game. (May/84)

ATTITUDES OF PARENTS

At the beginning of the study, it was found that parents were more likely to encourage boys than girls to use computers, although the difference did narrow considerably over the two years (Table 19). At the beginning, at site 8a, 82% of the boys said their parents had encouraged them to use the computers, compared with 26% of the girls. By the end of the second year, however, all of the boys and 80% of the girls who had been in the study for two years (site 8ab) had parental encouragement. During the two years of our study, some of the boys would bring magazines and Logo problems given to them by their fathers to school. This never happened with the girls. At the parent/teacher interviews, the teacher of site 8 spoke to the parents about their children's use of computers at home and reported his findings in his log book:

> The majority of the boys were receiving support and encouragement from at least one member of the family concerning their use of the computers. Talk was given in terms of the future. Answers like "yes, its a good thing they will be using it in engineering one day". I didn't find a similar pattern happening for the girls. (Feb./84)
>
> All boys have several games at home. Some girls have games, but all have word processing. (Feb./84)

CONFIDENCE IN USING COMPUTERS

In a questionnaire given at the end of each year of the study, the students were asked if they felt confident about their ability to use the computer, and if working with the computer had affected how they felt about themselves. In both sites 6 and 8, where the computer was a regular part of the daily class timetable, the boys more frequently gave positive responses to these questions (Figures 10.4 and 10.5). The percentage of boys expressing confidence remained at 100% throughout the study at site 8, but for the girls there was a considerable drop in the percentage expressing confidence during the second year. At site 6, all the boys in the first year of the study, all of those in the study for two years, and 80% of the new boys in the second year said that they were confident in their ability to use the computers. A higher percentage of boys than girls at these two sites also felt that working with the computers had increased their overall confidence (Figure 10.5). The one exception was the group of new boys in the second year at site 6, where a higher percentage of girls had an increase in confidence. At sites 7a and 10a a higher percentage of the girls felt confident in their abilities to use computers, but more boys reported an increase in their overall confidence since using the computers. Both these sites used computer laboratories rather than having computers in the classroom. Site 10a had twice as many girls as boys. At site 9 the computer was used on a voluntary basis although the students were expected to sign up for at least one computer slot per week.

Table 19

Percentage of Students Whose Parents had Encouraged Them to Use Computers

	1982-83 1st Year Students (a Sites)				1983-84 1st Year Students (b Sites)				1983-84 2nd Year Students (ab Sites)			
	Sept	Sept	June	June	Sept	Sept	June	June	Sept	Sept	June	June
	Boy	Girl	Boy	Girl	Boy	Girl	Boy	Girl	Boy	Girl	Boy	Girl
Site 11	58	100										
Site 10	60	73										
Site 9	64	31			88	55	75	33	86	100	71	43
Site 8	82	26			90	60	70	60	100	80	100	80
Site 6					42	40	50	50	33	75	67	50

Figure 10.4

Positive Responses at the End of Each Year by Junior- and Intermediate-Level Boys and Girls to "I Feel Confident About My Ability to Use Computers".

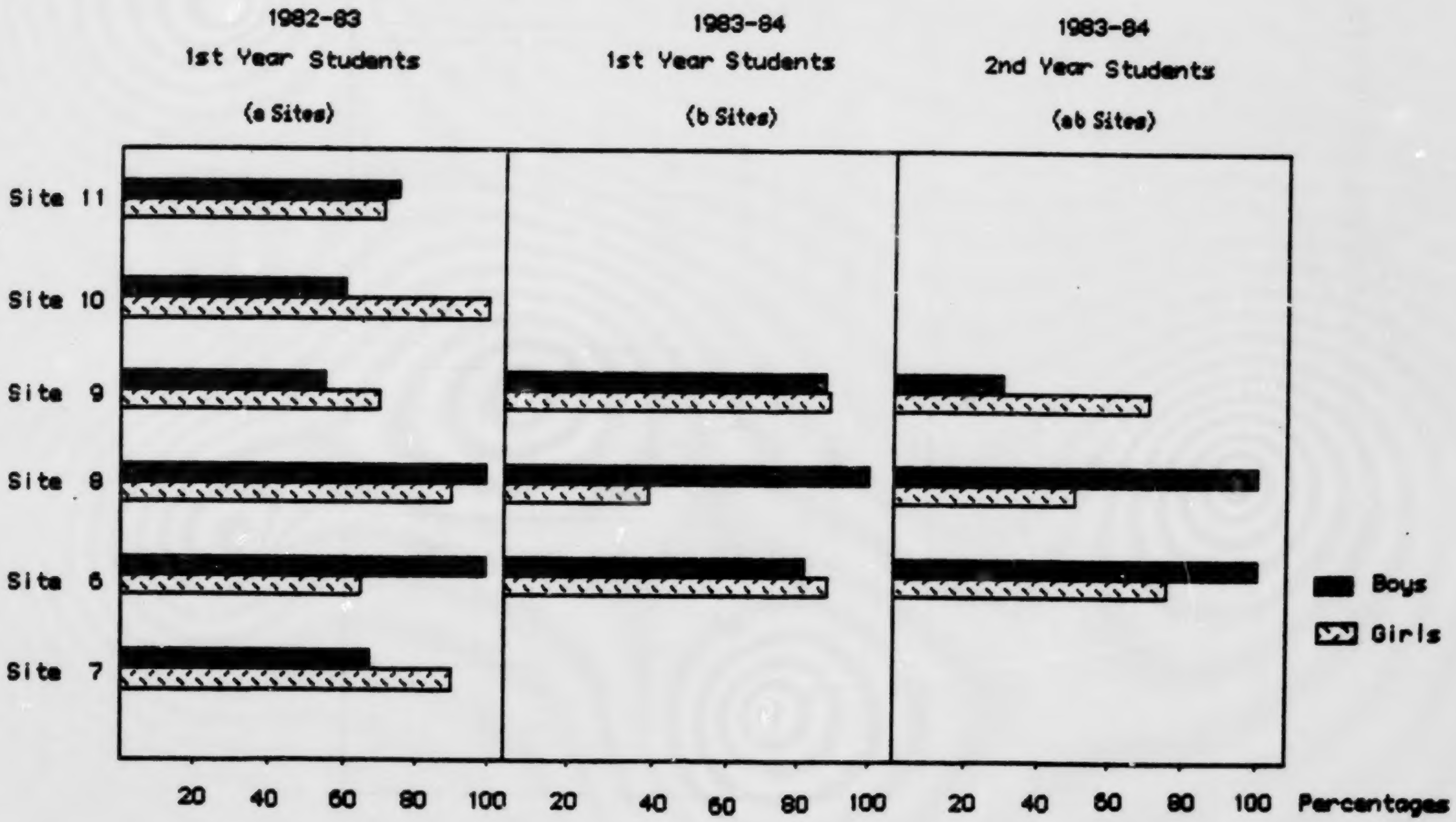
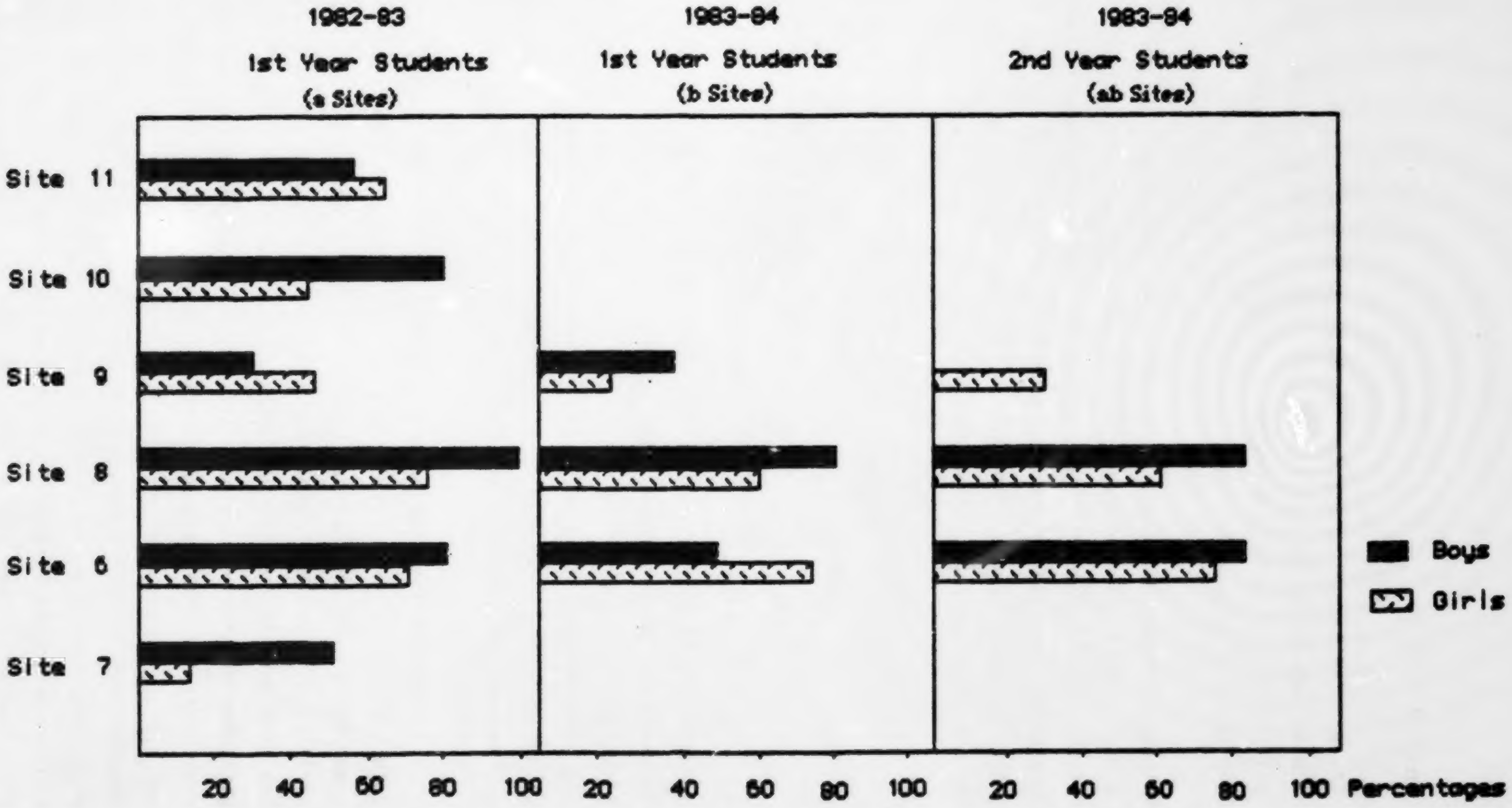


Figure 10.5

Positive Responses at the End of Each Year by Junior- and Intermediate-Level Boys and Girls to "Has Working on the Computer Affected How you Feel About Yourself?"



CONCLUSIONS

[Note: The issues raised in this chapter strongly point to the traditional technological schism between males and females. In order to gain greater insight into these issues, it was felt necessary to extend the discussion and to find possible connections between our findings and those of others.]

Although strong differential behaviour was found at site 8(a,b,ab) - a Grade 6/7 and Grade 7 class - there was some evidence that such differential behaviour might start as early as Kindergarten. One of the researchers, observing a Grade 1 class during the second year of the study, noticed that the boys frequently went from one machine to another, giving them two or three turns at the computers in one morning. The girls tended to use the computer once. On one occasion she observed the following:

> Jenny was working quietly by herself at the computer. Simon came to ask if he could sit at the empty chair, saying "I just want to watch". Jenny agreed somewhat reluctantly and, in no time, he was telling her what to do and leaned across her to press the keys. Jenny got up and walked away. (Nov./83)

Incidents like this were difficult for the teacher to notice since she was engaged with other students in the classroom. The students in this Grade 1 class had had a computer in Kindergarten the previous year. When the researcher asked the Kindergarten teacher who used the computer most frequently the previous year, she named ten boys and no girls. Susan Flieg (Kolata, 1984), a teacher at the Georgetown Day School in Washington, also found that when she let her students use the computer at recess and lunch time, only boys showed up.

It appears that the teacher's actions can inadvertently bias the appeal of computers. Both the nature of the challenges or assignments for the computer and the way they are presented by the teacher can have differential effects on boys and girls. For example, the girls of site 8(b,ab) complained that the challenges or assignments were too mathematical all the time and the "glory" was given to the person who could finish the challenge first. The girls had wanted to draw more pictures, to make more interesting designs, and to receive praise for their efforts whether they were the first to complete the work or not. However, despite the "who can do it first" challenges, the teacher was able to keep the competition between boys and girls manageable during the first year, when he set aside periods during which discoveries and new ideas could be shared and examined by the whole class. During the second year, when timetabling difficulties prevented him from holding such sessions, the girls indicated that they missed them and the competitive drive of the boys became much more overt. This was primarily to the detriment of the girls, but even some boys became bothered by it. The teacher of site 6(a,b,ab) tended to give challenges that were more open-ended and gave some challenges that asked students to make designs depicting how they felt about something. Praise was given for effort expended, and not always for who finished the challenge first. Sharing was strongly encouraged in both years. No apparent differences showed up in the computer work between the boys and girls in that class, although boys still tended to dominate in any boy-girl pairing while working at the computer. Susan Flieg also found that an atmosphere of co-operative learning was important for encouraging the girls to use computers.

Cultural factors outside the school also influence what is happening inside: traditional male and female interests were reflected in the students' activities. The Grade 3 teacher in this study described her students' work as follows:

> ... some of the girls did beautiful designs and patterns, while the boys tended to draw trucks and tractors.

Video games currently influence the social framework for computers in the public domain. Many video games involve killing and bombing, ideas which are not attractive to girls. The video arcade is a den of teenage male culture: few girls are seen there. With few exceptions, males design video games, write the software, and sell the machines. According to Dan Gutman, editor of Video Games, most games are designed by boys for other boys. The influence of video games could be seen in the students' work in this study. All classes from Grade 1 upwards had a PACMAN printout, almost always done by a boy. The games the boys made were often based on video games with which they were familiar and tended to have explosions and collisions. Among the girls only one drew a MISS PACKMAN, and the only game that could be found on any of the girls' disks was a number game rather than an action game.

One of the strongest cultural influences may be the advertising medium. Advertisements of computer games and home computers usually feature pictures of boys. In the movie "Wargame", the boy deftly operated the computer while the girl looked on in awe. The message is "computers are for boys". Children quickly pick up such messages. Such images also seem to enforce traditional stereotypes as to who possess technological competency. For example, when the teacher of site 6, a female, had a computer in her room that she was unable to fix, two girls came to her independently and suggested that she ask one of the male teachers for help, each naming a different one. The teacher found this rather upsetting since, as she said:

> ... these girls knew that these two men came to my room for instructions about the computers from me, but when there was a problem with a computer it was immediately "ask those two men for help". (Feb. 24/84)

It appears as if traditional role perceptions are highly persistent. In a survey done by Nancy Kreinberg and Elizabeth Stage (1983) at the Lawrence Hall of Science at the University of California at Berkeley, 445 girls and 428 boys from Grade 4 to 12 were asked to describe how they would use computers when they would be 30 years old. Typical answers from boys were that they would use them for finances, data processing, and games. The girls thought they would use them for housework. One Grade 6 girl from this survey commented:

> When I am thirty, I'll have a computer with long arms that can clean the house and cook the meals, and another to pay for the groceries.

Betty Beeson and Ann Williams (1983) two Ball State University researchers, studied the play pattern of twenty-five three to five year olds. They found that little girls' play choices have remained the same over time with age and that they focused on art projects and house play, while boys' activities have expanded to include house play. Such traditional activities and roles for boys and girls seem to be encouraged by parents as well. At the outset of this study, more boys than girls reported that their parents encouraged them to learn about computers, and more boys than girls tended to have a computer at home by the end of this study. Muira and Hess (1983), two social scientists at the University of California at Berkeley also found that, in California, boys who had microcomputers at home outnumbered girls by 25%. They surveyed computer camps run by a variety of sponsors, such as PTA, university, colleges, private and corporate enterprises, and found that boys outnumbered girls three to one at computer camps across the United States. When they analysed the ratio between boys and girls by the course level, they found that the proportion of girls in the beginning and intermediate classes was 28%, in advanced programming 14%, and in higher level courses that taught assembly language only 5%. They also found that as the cost of the sessions increased, the number of girls enrolled decreased. Several camp directors surveyed, suggested that parents, especially fathers, were actively interested in promoting computer awareness for sons but not for daughters.

Parental bias may also be operating at a much more fundamental level which might explain the different social and learning patterns between boys and girls that were observed in this study. Block (1981), who conducted a 10 year longitudinal study of very young children, found that parents tended to be much more protective of girls, keeping them close to home and giving them few opportunities to explore the unknown and to develop confidence in their problem-solving abilities. Boys, on the other hand, tended to be encouraged to explore, to search beyond the home, and to compete in sports and games. Block suggests that this early differential treatment between boys and and girls has a serious impact on how girls deal with the unknown. Since the girls in her study tended to be more protected and kept in structured situations, the girls eventually needed such structures in order to feel safe. Boys, on the other hand, had experienced many opportunities in dealing with the unknown and thus were not frightened by it: some actively set out to search for it. Block also suggests that the early play experiences, especially in team sports, help boys to develop a team spirit of working together to compete against others outside the group. Girls' early play patterns, on the other hand, are more solitary and less competitive. Such differences in approaches to computers appeared between the boys and girls at site 8. Whereas many of the boys were quite happy to experiment and discover things for themselves, the girls wanted greater initial direction and guidance. The girls, more than the boys, missed the class instructions and sharing sessions during the second year. Some boys set out to seek new knowledge and made new discoveries on their own. They, in turn, would share these with other boys but not with girls, although by the end of the year a few boys were beginning to express concern that one or two boys were no longer willing to share with them either.

Even though some factors that influence the differential use of computers between boys and girls may be due to long-term conditioning, there is very tentative evidence that the sex of the teacher, the way access to computers is organized in the class or in the school, and the nature or content of the computer activities, can all be readily modified to make the computer technology more attractive to girls. It would appear, therefore, that experiments to examine such modifications in detail need to be conducted, in order to assess the significance of any or all of these variables.

Part Four: Samples of Students' Work

11. TURTLE GEOMETRY

12. LOGO SPRITES

13. KOALA PAD GRAPHICS

14. MUSIC

15. WORD PROCESSING

16. LOGO TEXT AND INTERACTIVE STORIES

PREAMBLE

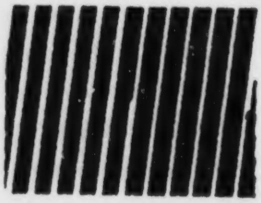
Although the intention at the outset of this research was to explore, in depth, several "creative" software packages, the slow development of such packages at that time made this impossible. Logo, which was available from the outset, was therefore the main creative software used throughout the study. Within Logo, major attention was given to Turtle Geometry, although its word, list, and music capabilities and Text Editor were also explored to a limited extent. A Grade 1 class used the Logo editor as a simple word processor. Four months into the study, the Bank Street Writer word processing package became available and several of the classes studied used it as an integral part of their writing program. Late in the second year of the study, the Koala Pad was made available to three classes and Logo Sprites to one class. Musicland arrived only within weeks of the end of the study, hence, there was only time to examine this software with a small group of students from a Grade 3 class. The length and details of the various chapters in this section, therefore, reflect not only how teachers and students used the various software but also its availability.

11. TURTLE GEOMETRY

INTRODUCTION

The samples of students' computer output were selected from approximately 4000 individual printouts collected during the study. In spite of this large data sample, many other examples were not recorded because students did not always make a printout of their activity or save it on disk.

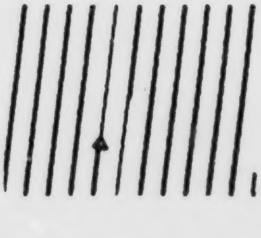
Based on researchers' and teachers' observations, it became clear that a given computer activity often contained elements of critical learning that were not always evident or visible from examining the computer output alone. In looking at students' work, it was therefore necessary to look beyond an individual picture since it often told only part of the story - and sometimes a trivial part. For example, take the following printout:



The lines, by themselves, convey very little of the learning process that the two Grade 1 students - Ned and Sammy - were engaged in. The lines plus the dialogue between the students while they were drawing these lines, however, revealed another dimension:

> Ned: "Sammy, make it [the turtle] go all over.
> O.K.?"

Sammy entered RT 6 FD 5009 which resulted in the following picture:



> Ned: "I know what it is - a river and the turtle is a boat. Let's fill in the river."

Sammy put in FD 7000 which filled in more of the screen.

> Sammy: "Let's make the river all muddy."

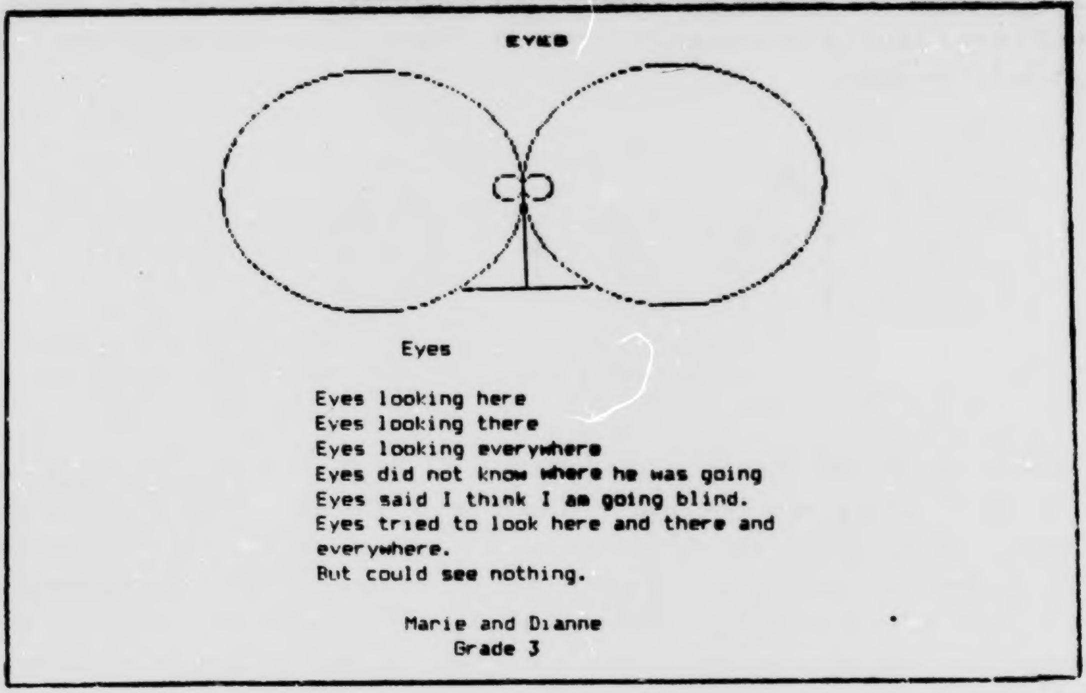
He then entered FD 8000 which produced the first illustration. At this point they both had a good laugh and proceeded to do something else.

In another example, two Grade 3 students started an activity by drawing a circle. They then decided to make a set of adjoining circles: one "left" and one "right". This reminded them of eyes and an intense discussion followed as to what sorts of eyes were possible and in the end they settled on circles within circles (Figure 11.1). Once that had been accomplished, they jointly composed a poem about eyes and used the computer and the Bank Street Writer for recording it. Excited giggles punctuated their activity as they evaluated their imaginative ideas and alternatives.

Humour was quite often an important part in students' activities. Chatter and laughter about "funny" designs, such as "an egg in a duck's belly" were common. Older students enjoyed the unexpected result if it struck them as incongruous and they often reflected their sense of humour in the names they gave to their procedures. This process of personalizing, and the ability to integrate different levels of thinking seemed to be a very important aspect of the appeal and fascination of Logo at all grade-levels. Many students personalized their procedures or pictures by giving them their own names. For example, the familiar procedure POLYSPI became MYSTERIOUS, FANTASIA, FATSO, DANDRUFF, SNOW, GARDEN, and WAVES, in one of the intermediate-level classes. Also, two Grade 3 students working together on the same picture put their personal stamp on it by one calling it a 'cow' and the other a 'horse' (Figure 11.2).

Figure 11.1

Extending Graphics: 'EYES', A Drawing and Poem by Two Grade 3 Students



EYES

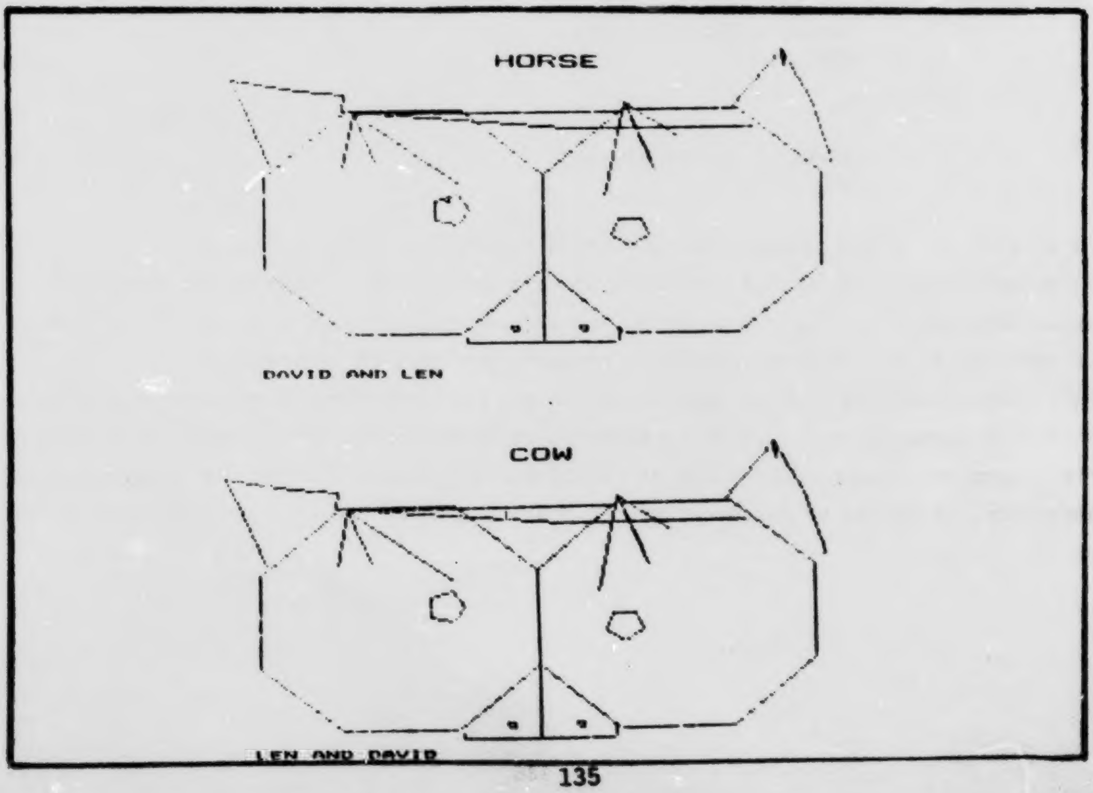
Eyes

Eyes looking here
Eyes looking there
Eyes looking everywhere
Eyes did not know where he was going
Eyes said I think I am going blind.
Eyes tried to look here and there and
everywhere.
But could see nothing.

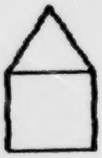
Marie and Dianne
Grade 3

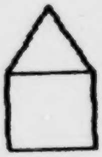
Figure 11.2

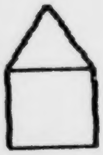
The Need to Personalize a Computer Activity: A "COW" and "HORSE" Drawn Jointly by Two Grade 3 Students



The graphic output of students' computer activities alone also does not reveal the underlying programming complexities that were involved in creating the design. For example, "houses" were produced at every grade level. Some looked the same in design but involved quite different thinking or programming strategies. The following three houses were among the students' printouts:



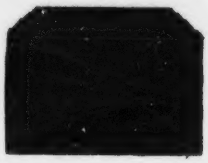




The house on the left was drawn by a Kindergarten child with Instant Logo, the middle one was drawn in the Direct Draw mode by a Grade 8 student ten minutes after being introduced to the four basic commands (FD, BK, RT, LT) in Logo, and the house on the right was drawn by two Grade 3 students four months after the class received the computer (after approximately four hours of hands-on exposure to Logo), and after the teacher had given them a lesson on writing procedures that used sub-procedures. Their drawing was made by executing the following procedures:

```
TO HOUSE

D FD 50 RT 30 S
END

TO D

REPEAT 4 [FD 50 RT 90]
END

TO S

REPEAT 3 [FD 50 RT 120]
END
```

In addition, the graphic output can also hide rather intricate logical thinking and problem-solving strategies. A relatively simple drawing of a "house" can demand a considerable amount of logical thinking and problem-solving skills as is illustrated by the misadventures of one intermediate-level student, depicted in Figure 11.3-A. Further complexities involving problem-solving skills were evident when students were working with top-level procedures, i.e., defining a procedure with modular components. Connecting the various components created problems of relative size and positioning that needed careful examination. Examples of misadventures in drawing a house and in combining letters into words are shown in Figure 11.3-B. Furthermore, apparently simple tasks can demand careful analysis of appropriate problem-solving strategies that involve elements of composition as well as decomposition. For example, a task such as creating the following shape



with a Logo implementation that does not have a "fill" command can be approached in many different ways. An analysis of one intermediate-level student's approach is presented in Figure 11.4 This student's strategy formed the basis for a brief discussion between the teacher and the student about alternative strategies that could have been employed in solving the problem.

Another element that is hidden in the final output is the dynamic nature of the turtle graphics activity. Students were often fascinated by the evolution of various designs and shapes as the "turtle" executed the instructions (Figure 11.5). This dynamic nature greatly encouraged the students' curiosity to experiment extensively with relatively simple concepts. Also not evident from the computer printout is the effect of colour, in a static sense but also in a dynamic sense, since many students enjoyed incorporating various pen-colours and background colours into their designs. Particularly captivating for students as young as Grade 1 were the flashing background colours which caused the designs to take on different visual impressions. Examples of such designs created by one of the intermediate-level students are presented in Figure 11.6. Another dynamic element that is hidden from a printed page is the effect of animation and other dimensions, such as sound. For example, hidden from this static snapshot of a watertap are the motion and sound of a dripping faucet.

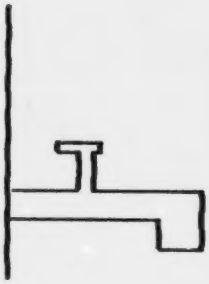
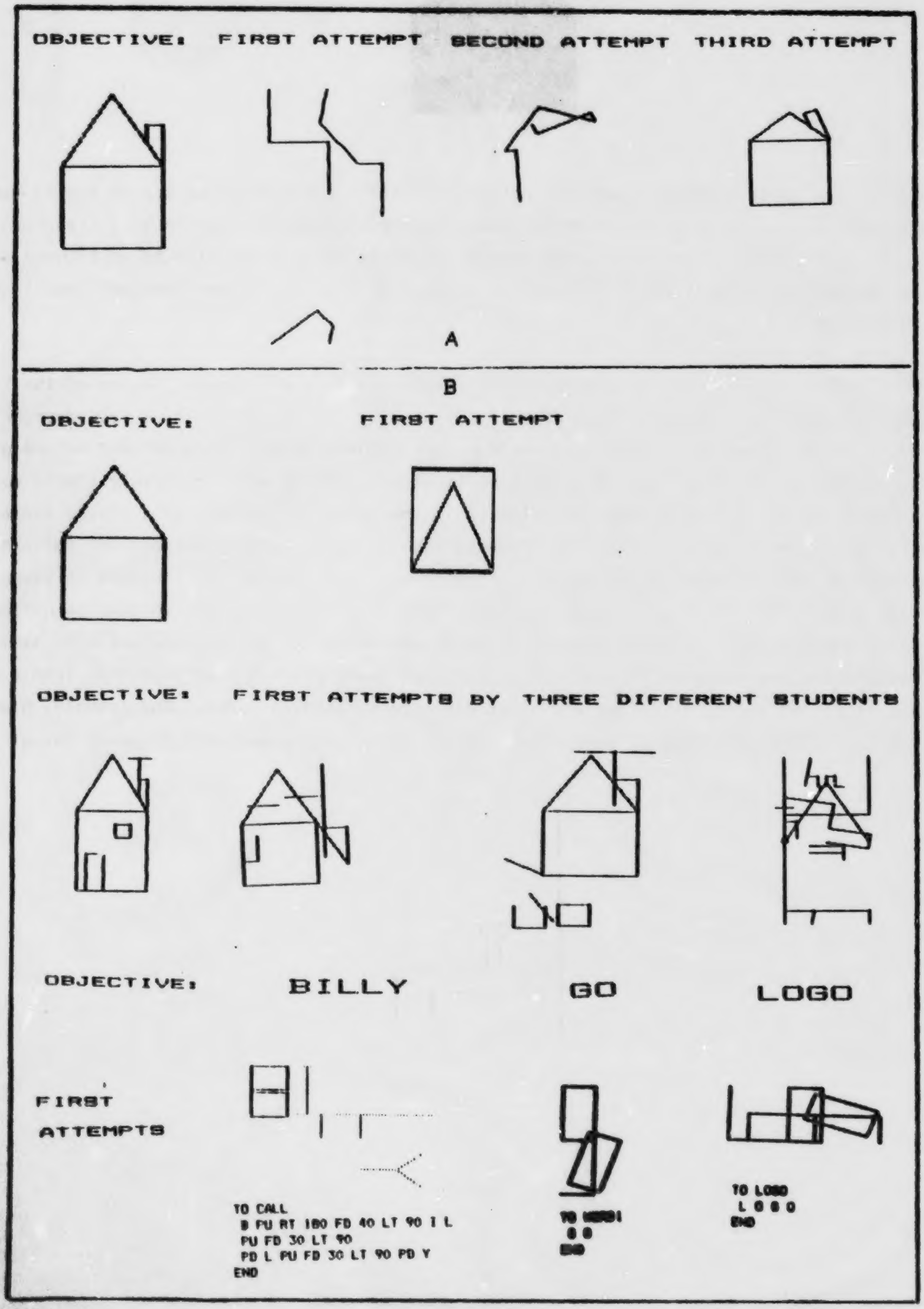


Figure 11.3

A: One Example of Typical Misadventure in Drawing a House in Turtle Geometry

B: Examples of Typical Misadventures in Combining Procedures into Top-Level Procedures


OBJECTIVE:
FIRST ATTEMPT
SECOND ATTEMPT
THIRD ATTEMPT
A
B
OBJECTIVE:
FIRST ATTEMPT
OBJECTIVE:
FIRST ATTEMPTS BY THREE DIFFERENT STUDENTS
OBJECTIVE:
BILLY
GO
LOGO
FIRST ATTEMPTS

```
TO CALL
 B PU RT 180 FD 40 LT 90 I L
 PU FD 30 LT 90
 PD L PU FD 30 LT 90 PD Y
END
```

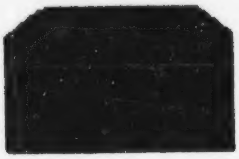
```
TO [illegible]
 G O
END
```

```
TO LOGO
 L O G O
END
```

Figure 11.4

An Example of a Problem Solving Strategy by a Grade 8 Student

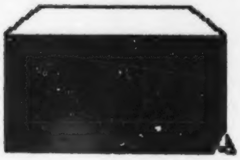
OBJECTIVE:



STAGE 1

```
REPEAT 90 [FD 60 BK 60 RT 90 FD 1 LT 90]
```

STAGE 2



```
LT 90 FD 90 RT 90 FD 61 RT 45 FD 20
BK 20 LT 45 BK 61 RT 90
FD 90 LT 90 FD 61 LT 45 FD 20 LT 45
FD 62 BK 62 RT 45 BK 20 RT 45 BK 61
```

STAGE 3

```
FD 61 LT 45 FD 20 LT 45 FD 62 LT 90
REPEAT 60 [FD 15 BK 15 LT 90 FD 1 RT 90]
```

STAGE 4

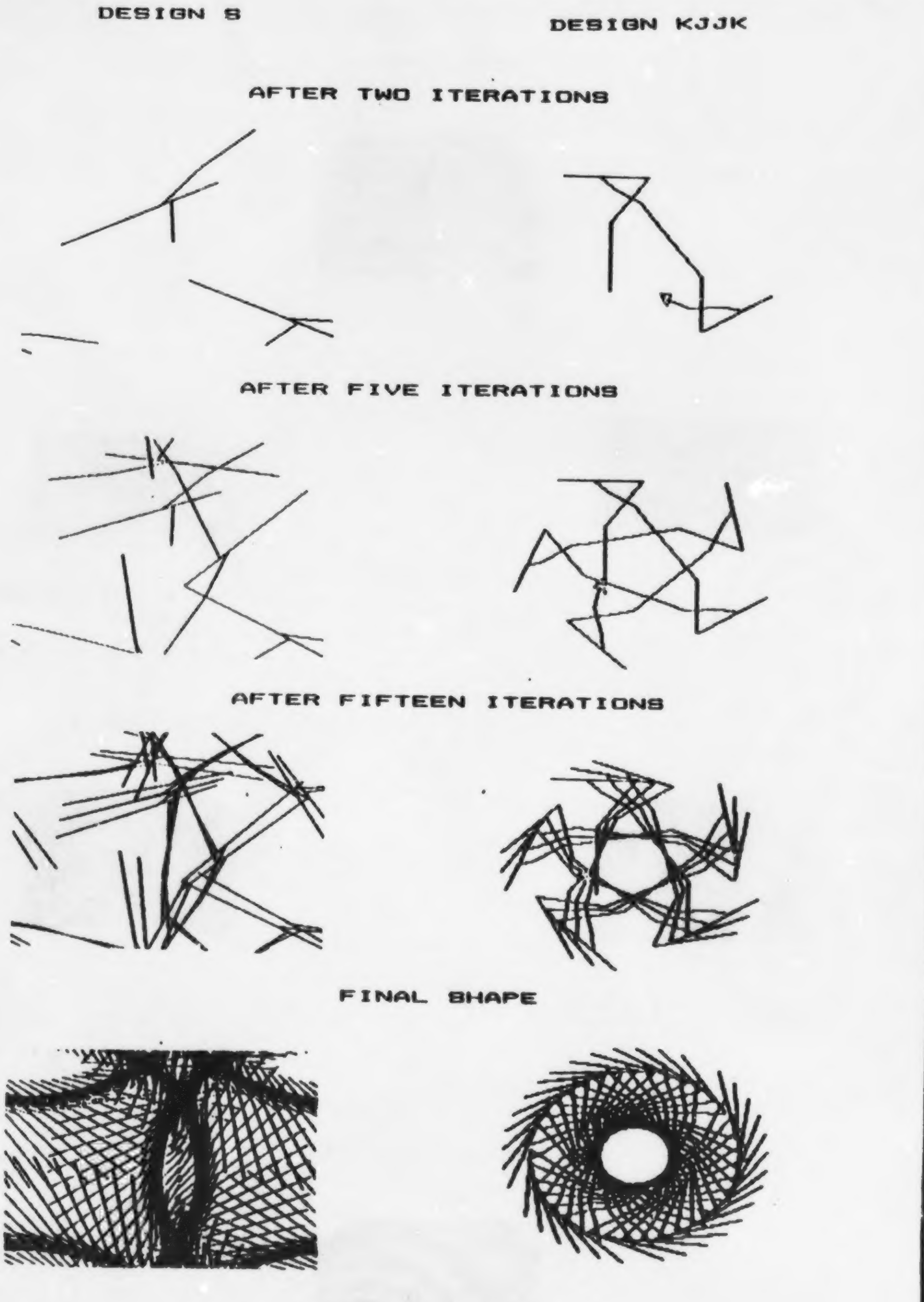
```
FD 15 LT 90 FD 15 LT 135
REPEAT 20 [FD 20 BK 20 LT 45 FD 1 RT 45]
LT 45 FD 72 RT 135
REPEAT 20 [FD 20 BK 20 RT 45 FD 1 LT 45]
```

FINAL STAGE

```
LT 135 FD 19 LT 90 FD 60
RT 90 FD 1 RT 90 FD 60 BK 60
```

Figure 11.5

Two Designs Depicting the Dynamic Nature of Turtle Graphics

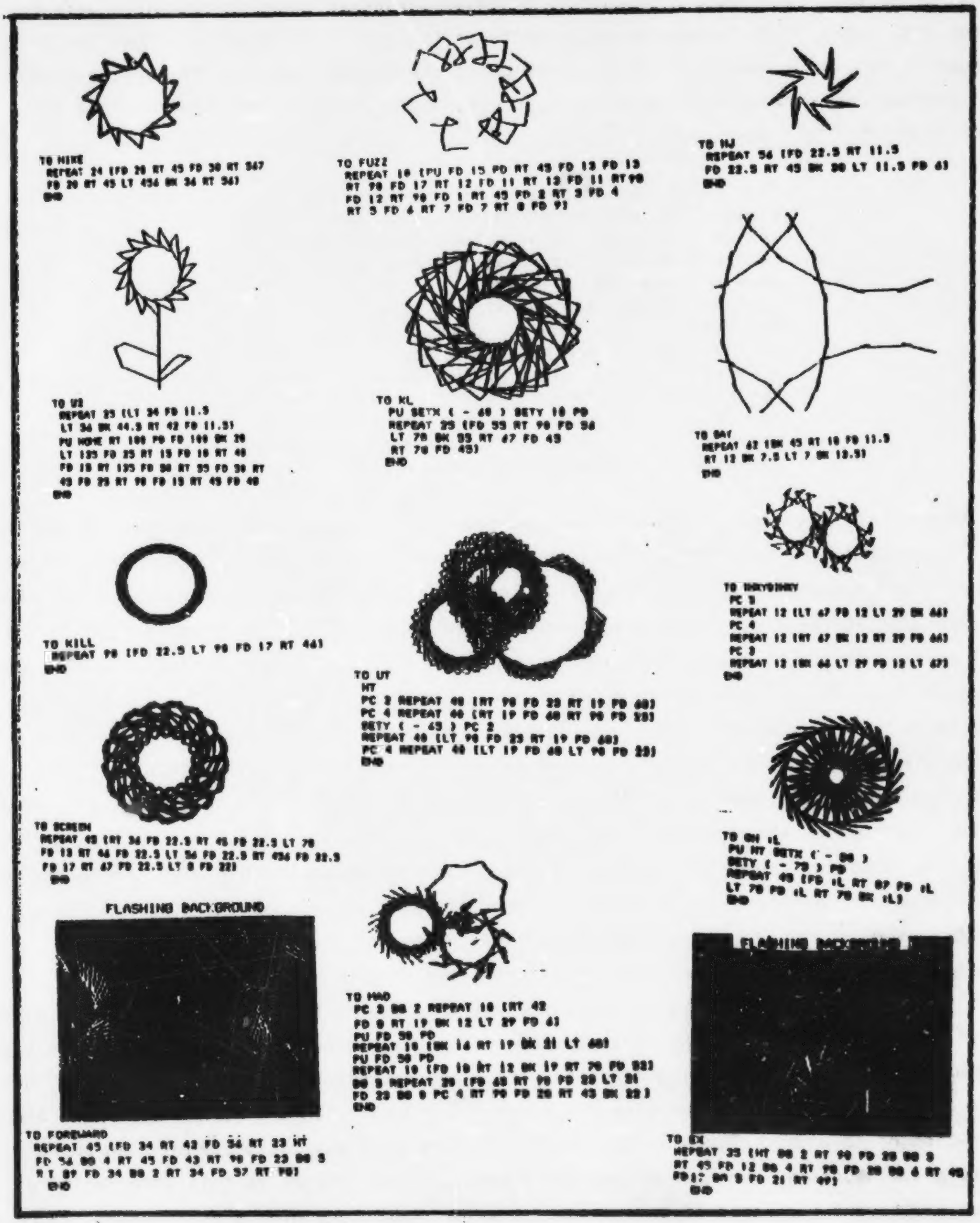

DESIGN S
DESIGN KJJK
AFTER TWO ITERATIONS
AFTER FIVE ITERATIONS
AFTER FIFTEEN ITERATIONS
FINAL SHAPE

```
TO S
 HT
 REPEAT 99 [FD 46 RT 67 FD 46 BK 156 FD 99
  LT 23 FD 56 RT 8 FD 56]
END
```

```
TO KJJK
 REPEAT 34 [FD 58 RT 34 FD 45 RT 56 BK 56 FD 23
  RT 45 FD 12 LT 12 FD 23 RT 23 FD 15]
END
```

Figure 11.6

Explorations with REPEAT Statements and Colour by an Intermediate-Level Student



```
TO HIKE
 REPEAT 24 [FD 20 RT 45 FD 30 RT 567
 FD 20 RT 45 LT 456 BK 36 RT 36]
END
```

```
TO FUZZ
 REPEAT 16 [PU FD 15 PD RT 45 FD 13 FD 13
 RT 90 FD 17 RT 12 FD 11 RT 13 FD 11 RT 90
 FD 12 RT 90 FD 1 RT 45 FD 2 RT 3 FD 4
 RT 5 FD 6 RT 7 FD 7 RT 8 FD 9]
```

```
TO HJ
 REPEAT 56 [FD 22.5 RT 11.5
 FD 22.5 RT 45 BK 30 LT 11.5 FD 6]
END
```

```
TO U2
 REPEAT 25 [LT 34 FD 11.5
 LT 34 BK 44.5 RT 42 FD 11.3]
 PU HOME RT 180 PD FD 100 BK 20
 LT 135 FD 25 RT 15 FD 10 RT 40
 FD 10 RT 135 FD 30 RT 35 FD 30 RT
 45 FD 25 RT 90 FD 15 RT 45 FD 40
END
```

```
TO KL
  PU SETX ( - 60 ) SETY 10 PD
  REPEAT 25 [FD 55 RT 90 FD 56
   LT 78 BK 55 RT 67 FD 45
   RT 78 FD 45]
  END
```

```
TO DAY
 REPEAT 62 [BK 45 RT 10 FD 11.5
 RT 12 BK 7.5 LT 7 BK 13.5]
END
```

```
TO KILL
 REPEAT 90 [FD 22.5 LT 90 FD 17 RT 44]
END
```

```
TO UT
 HT
 PC 2 REPEAT 40 [RT 90 FD 23 RT 19 FD 60]
 PC 4 REPEAT 40 [RT 19 FD 60 RT 90 FD 23]
 SETY ( - 45 ) PC 2
 REPEAT 40 [LT 90 FD 23 RT 19 FD 60]
 PC 4 REPEAT 40 [LT 19 FD 60 LT 90 FD 23]
 END
```

```
TO INKYDINKY
 PC 5
 REPEAT 12 [LT 67 FD 12 LT 29 BK 66]
 PC 4
 REPEAT 12 [RT 67 BK 12 RT 29 FD 66]
 PC 3
 REPEAT 12 [BK 66 LT 29 FD 12 LT 67]
END
```

```
TO SCREEN
 REPEAT 45 [RT 34 FD 22.5 RT 45 FD 22.5 LT 78
 FD 13 RT 44 FD 22.5 LT 56 FD 22.5 RT 436 FD 22.5
 FD 17 RT 67 FD 22.5 LT 8 FD 22]
  END
```

```
TO GH :L
 PU HT SETX ( - 80 )
 SETY ( - 70 ) PD
 REPEAT 45 [FD :L RT 87 FD :L
 LT 70 FD :L RT 70 BK :L]
 END
```

```
TO MAD
 PC 3 BG 2 REPEAT 10 [RT 42
 FD 8 RT 19 BK 12 LT 29 FD 6]
 PU FD 50 PD
 REPEAT 10 [BK 14 RT 19 BK 21 LT 46]
 PU FD 50 PD
 REPEAT 10 [FD 10 RT 12 BK 19 RT 70 FD 52]
 BG 5 REPEAT 20 [FD 45 RT 90 FD 23 LT 21
 FD 23 BG 0 PC 4 RT 90 FD 20 RT 43 BK 22]
 END
```

```
TO FOREWARD
 REPEAT 45 [FD 34 RT 42 FD 56 RT 23 HT
 FD 56 BG 4 RT 45 FD 43 RT 90 FD 23 BG 5
 RT 89 FD 34 BG 2 RT 34 FD 57 RT 90]
  END
```

```
TO EX
 REPEAT 35 [HT BG 2 RT 90 FD 28 BG 3
 RT 45 FD 12 BG 4 RT 90 FD 28 BG 6 RT 45
 FD 17 BG 5 FD 21 RT 49]
   END
```

One of the most compelling features of the computer was the speed with which students obtained feedback on their activity. A misspelled primitive or procedure was immediately recognized, and students had to make the corrections before the computer could proceed. Several students commented on this aspect. Observations like "If I keep this up, I am bound to learn how to spell this dumb word" were not uncommon. Also, if students wanted to achieve a particular goal (drawing), they quickly discovered whether their instructions were correct or not and, again, they could make adjustments on the spot. Children no longer had to wait an hour, a day, or a week for this feedback until the teacher had time to check the work. The computer was also unforgiving in that it demanded precision. One student from the learning disability class wrote:

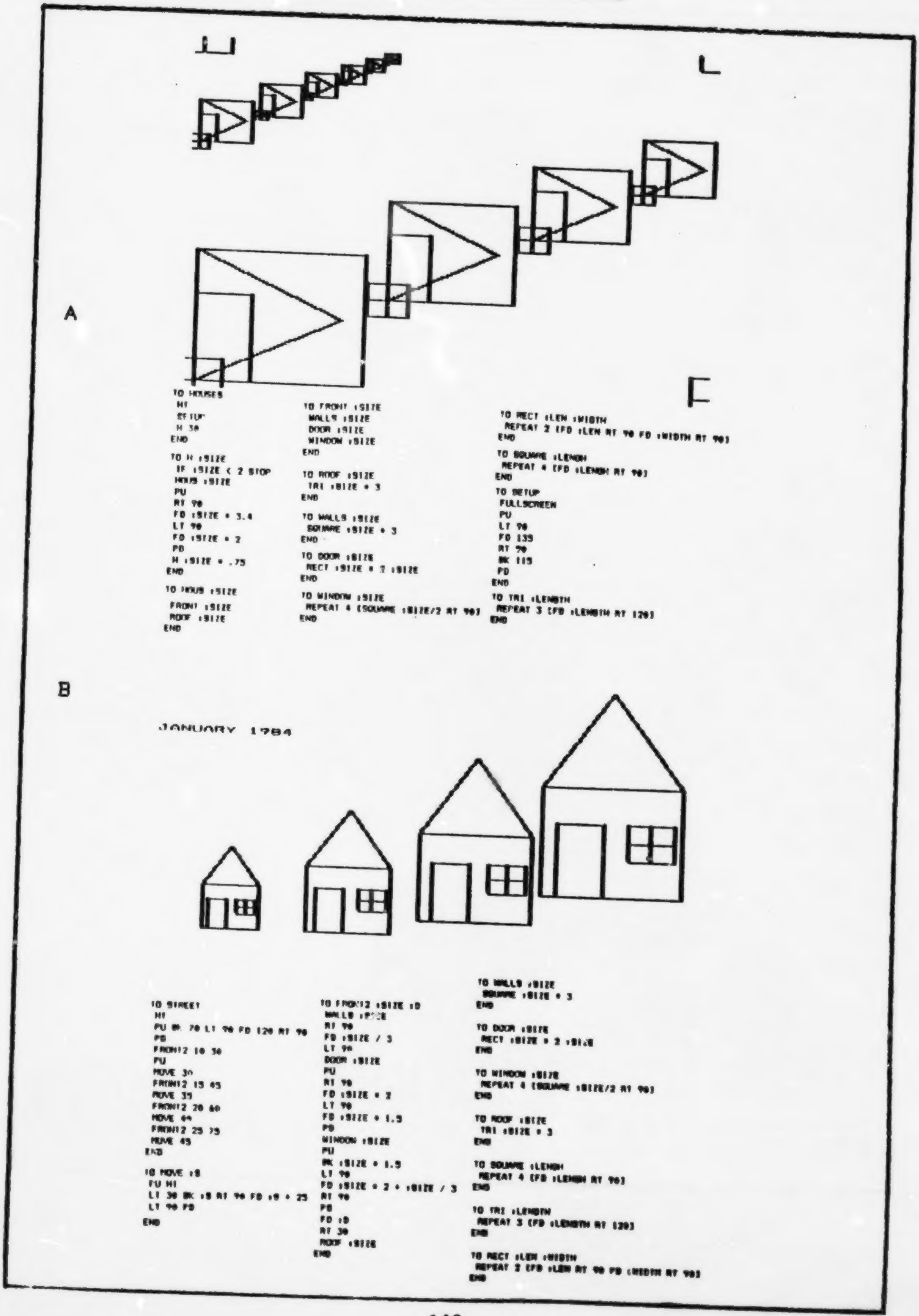
> The first day I used the computer in our class. It was very exciting. I discovered angles to make octagon and other strange things to make. The first thing we did on the computer was our initials. It took a lot of time to finish it and it was a lot of fun. Sometimes I felt like to pick it up and throw it out the window, because I would do it and it would be wrong and I would have to look for the mistake in the edit mode but I had a lot of patience to do it. It made me realize that computer can help me in my learning as in my spelling and remembering. (June/83)

Many of the examples collected from students involved procedures that were copied from manuals, textbooks or formulae given to them by their teachers. Not uncommon were activities that involved concepts or programming techniques that were beyond the students' level of understanding at the time. Students, however, used such copied procedures as "tools" and combined them in creative ways. They also chose to work "backwards" at times - either out of choice or necessity. For example, a junior-level student copied several procedures for a set of variable houses from one of the Logo manuals. When she ran the procedures, she did not receive the expected result because she had failed to copy a critical procedure. This "bug" led her to examine the meaning of the various procedures more closely, and eventually enabled her not only to find the missing piece but to modify the variable input to her liking (Figure 11.7). In examining students' computer output alone, it was impossible with the methodology of this study, to determine at all times whether students understood the underlying concepts that they used, or not. In some instances, through careful direct observations and questioning, it seemed clear that students did indeed understand what they were doing; in others, all that could be said with certainty was that students had been exposed to a given concept and were using it. Many students appeared to have a need to explore extensively with given mathematical or programming concepts before these concepts became "their own". The degree of experimentation by one intermediate-level student with the REPEAT statement and a combination of 45 and 90 degree angles shown in Figure 11.8 was not uncommon even among primary-grade students. Whether or not there were critical stages in this internalizing process was beyond the scope of this study. However, our study did determine that teachers who allowed students to explore, and who assisted them in exploring "advanced" ideas, were continually surprised at how much students at all ages and abilities were able to grasp and understand.

Figure 11.7

A: A Picture Illustrating the Result of Incorrectly Copying Procedures From a Manual Without a Clear Understanding of Them by Two Grade 6 Students

B: The Correct Picture and Modified Procedures After They Understood What They Were Doing



A

```
TO HOUSES
 HT
 SETUP
 H 30
END

TO H :SIZE
 IF :SIZE < 2 STOP
 HOUS :SIZE
 PU
 RT 90
 FD :SIZE * 3.4
 LT 90
 FD :SIZE * 2
 PD
 H :SIZE * .75
END

TO HOUS :SIZE
 FRONT :SIZE
 ROOF :SIZE
END
```

```
TO FRONT :SIZE
 WALLS :SIZE
 DOOR :SIZE
 WINDOW :SIZE
END

TO ROOF :SIZE
 TRI :SIZE * 3
END

TO WALLS :SIZE
 SQUARE :SIZE * 3
END

TO DOOR :SIZE
 RECT :SIZE * 2 :SIZE
END

TO WINDOW :SIZE
 REPEAT 4 [SQUARE :SIZE/2 RT 90]
END
```

```
TO RECT :LEN :WIDTH
 REPEAT 2 [FD :LEN RT 90 FD :WIDTH RT 90]
END

TO SQUARE :LENGH
 REPEAT 4 [FD :LENGH RT 90]
END

TO SETUP
 FULLSCREEN
 PU
 LT 90
 FD 135
 RT 90
 BK 115
 PD
END

TO TRI :LENGTH
 REPEAT 3 [FD :LENGTH RT 120]
END
```

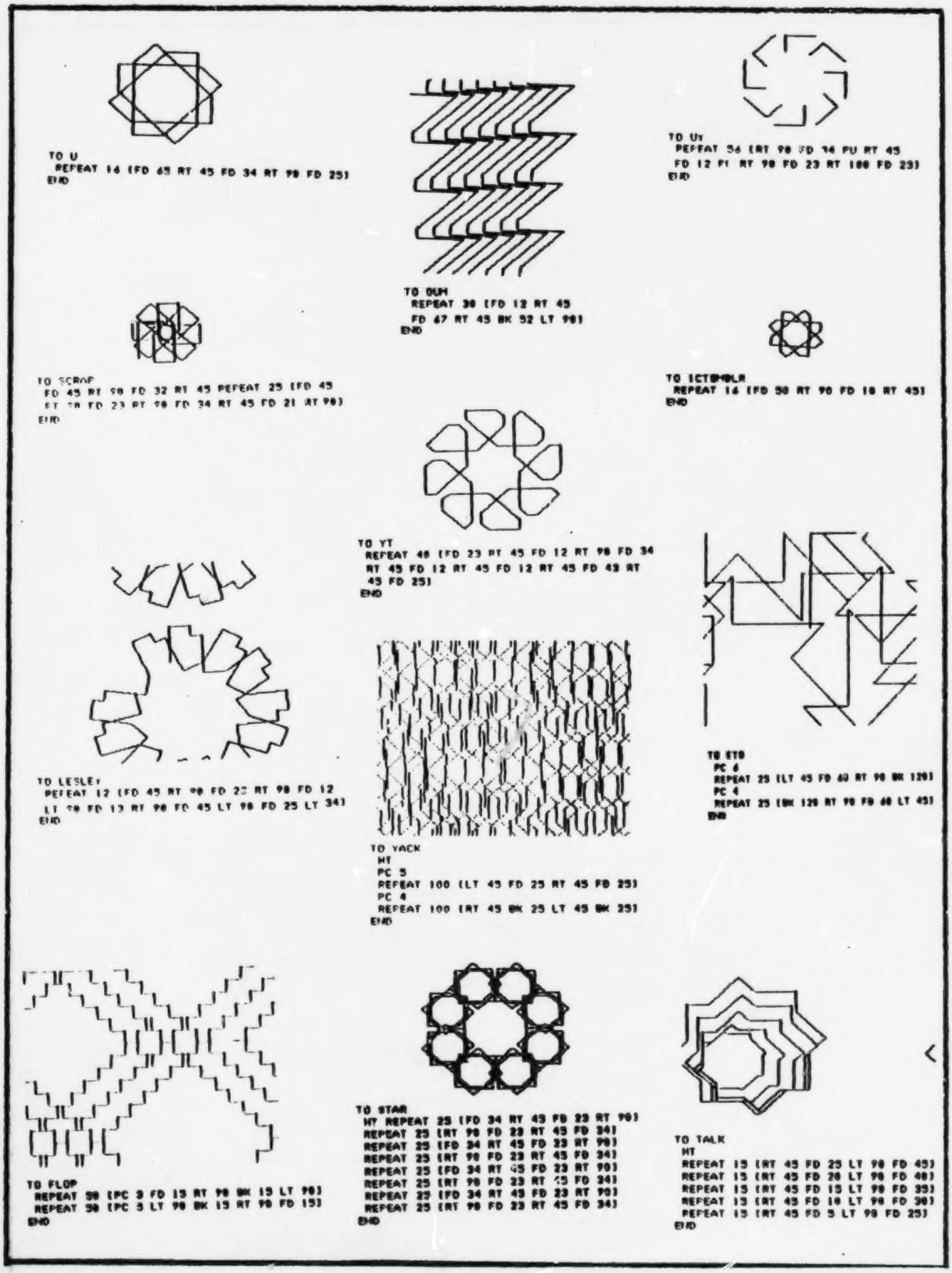
B

```
TO STREET
 HT
 PU BK 70 LT 90 FD 120 RT 90
 PD
 FRONT2 10 30
 PU
 MOVE 30
 FRONT2 15 45
 MOVE 35
 FRONT2 20 60
 MOVE 40
 FRONT2 25 75
 MOVE 45
END

TO MOVE :S
 PU HT
 LT 30 BK :S RT 90 FD :S + 25
 LT 90 PD
END
```

```
TO FRONT2 :SIZE :D
 WALLS :SIZE
 RT 90
 FD :SIZE / 3
 LT 90
 DOOR :SIZE
 PU
 RT 90
 FD :SIZE * 2
 LT 90
 FD :SIZE * 1.5
 PD
 WINDOW :SIZE
 PU
 BK :SIZE * 1.5
 LT 90
 FD :SIZE * 2 + :SIZE / 3
 RT 90
 PD
 FD :D
 RT 30
 ROOF :SIZE
END
```

```
TO WALLS :SIZE
 SQUARE :SIZE * 3
END

TO DOOR :SIZE
 RECT :SIZE * 2 :SIZE
END

TO WINDOW :SIZE
 REPEAT 4 [SQUARE :SIZE/2 RT 90]
END

TO ROOF :SIZE
 TRI :SIZE * 3
END

TO SQUARE :LENGH
 REPEAT 4 [FD :LENGH RT 90]
END

TO TRI :LENGTH
 REPEAT 3 [FD :LENGTH RT 120]
END

TO RECT :LEN :WIDTH
 REPEAT 2 [FD :LEN RT 90 FD :WIDTH RT 90]
END
```

Figure 11.8
Experimentations by an Intermediate-Level Student
with Angles of 45 and 90 Degrees



```
TO U
 REPEAT 16 [FD 65 RT 45 FD 34 RT 90 FD 25]
END
```

```
TO DUH
 REPEAT 30 [FD 12 RT 45
 FD 67 RT 45 BK 52 LT 90]
END
```

```
TO UY
 REPEAT 56 [RT 90 FD 34 PU RT 45
 FD 12 PD RT 90 FD 23 RT 180 FD 23]
END
```

```
TO SCRAP
 FD 45 RT 90 FD 32 RT 45 REPEAT 25 [FD 45
 RT 90 FD 23 RT 90 FD 34 RT 45 FD 21 RT 90]
END
```

```
TO ICTEMBLR
 REPEAT 16 [FD 50 RT 90 FD 10 RT 45]
END
```

```
TO YT
 REPEAT 40 [FD 23 RT 45 FD 12 RT 90 FD 34
 RT 45 FD 12 RT 45 FD 12 RT 45 FD 43 RT
 45 FD 25]
END
```

```
TO LESLEY
 REPEAT 12 [FD 45 RT 90 FD 23 RT 90 FD 12
 LT 90 FD 13 RT 90 FD 45 LT 90 FD 25 LT 34]
END
```

```
TO YACK
 HT
 PC 5
 REPEAT 100 [LT 45 FD 25 RT 45 FD 25]
 PC 4
 REPEAT 100 [RT 45 BK 25 LT 45 BK 25]
END
```

```
TO ETD
 PC 6
 REPEAT 25 [LT 45 FD 60 RT 90 BK 120]
 PC 4
 REPEAT 25 [BK 120 RT 90 FD 60 LT 45]
END
```

```
TO FLOP
 REPEAT 50 [PC 3 FD 15 RT 90 BK 15 LT 90]
 REPEAT 50 [PC 5 LT 90 BK 15 RT 90 FD 15]
END
```

```
TO STAR
 HT REPEAT 25 [FD 34 RT 45 FD 23 RT 90]
 REPEAT 25 [RT 90 FD 23 RT 45 FD 34]
 REPEAT 25 [FD 34 RT 45 FD 23 RT 90]
 REPEAT 25 [RT 90 FD 23 RT 45 FD 34]
 REPEAT 25 [FD 34 RT 45 FD 23 RT 90]
 REPEAT 25 [RT 90 FD 23 RT 45 FD 34]
 REPEAT 25 [FD 34 RT 45 FD 23 RT 90]
 REPEAT 25 [RT 90 FD 23 RT 45 FD 34]
END
```

```
TO TALK
 HT
 REPEAT 15 [RT 45 FD 25 LT 90 FD 45]
 REPEAT 15 [RT 45 FD 20 LT 90 FD 40]
 REPEAT 15 [RT 45 FD 15 LT 90 FD 35]
 REPEAT 15 [RT 45 FD 10 LT 90 FD 30]
 REPEAT 15 [RT 45 FD 5 LT 90 FD 25]
END
```

TEACHING PHILOSOPHIES: DIRECTION VS. DISCOVERY

Logo, with its philosophical foundation based on giving students control over their own learning, regenerated the debate about the meaning of creativity and about the appropriate teaching strategies that would allow creativity to flourish within an educational setting. The discussion among the teachers in this study was somewhat reminiscent of the educational debate of the 1960s: should the teacher get out of the way of students and allow them to explore without any directions or corrections, or should the teacher play an active part in directing a student's learning activities? All of the teachers in the study started with a "hands-off" approach by giving students only the basic turtle geometry commands: FORWARD; BACK; RIGHT; and LEFT. Other simple primitives such as PENUP, PENDOWN, BACKGROUND, and PEN-COLOR were added later. The students were then asked to explore with those primitives on their own and to request additional information as they needed it. This approach had limited success since Kindergarten students needed a simplified Logo and other students were looking for guidance. Many of the students did not have enough basic programming knowledge or experience to know what kinds of questions to ask. Many students also expressed a need to be challenged and to perceive a sense of "progress". Especially at the outset, students felt limited in their ability to engage in activities that were exciting to them. This feeling gradually lessened as students gained more experience with the Logo language and with taking greater responsibility for their own learning. Students who were able to take charge of their own inquiry process, still needed help with syntactical or programming questions - at least some direction as to where they could find the answer - or with stubborn "bugs" that they encountered. All teachers eventually developed strategies that blended direction and support with periods of free exploration.

Direction was usually given in the form of a lesson, a series of activity cards placed by the computer, assignments, or specific challenges that either took advantage of what students already knew or that required them to look for new knowledge. In most instances, the assignment or challenge was defined in broad enough terms that great individuality could still be exercised in carrying out the activity. Challenges were generally treated as optional activities. These "directions" served to help students learn the syntax of the Logo language as well as to demonstrate possible applications for them. Older students also had access to a manual for independent learning and exploration. Lessons or class discussions were often given when the teacher perceived that students "were ready" for a new concept. Quite often, the concepts discussed were drawn from students' own activities, questions, or accidental discoveries at the computer. Sufficient time was allowed between lessons or assignments so that students could continue to explore with their newly gained skills, combine them with old ones, or search out new ones on their own in a free and undirected way. Such periods drew heavily on students' creative abilities and demanded a degree of confidence in "laying bare" their ideas in front of their teachers and peers for which many students were not quite ready. Many students, even as young as Kindergarten, were afraid of failure, of not pleasing their teacher, or of appearing foolish to their peers. Those students had to be assured that exploration for its own sake was a legitimate activity whether it led to immediate "success" or not. Students also needed a supportive environment that did not evaluate every attempt on an absolute scale but allowed attempts to become a basis for further discussion and exploration. Students were sustained in their explorations to some degree because Turtle Geometry generally allowed students to receive pleasing results, and the computer facilitated the process of making corrections by giving fast feedback, and through easy manipulation of syntax and editing. As one junior-level student put it:

> When you are wrong on paper it stays wrong, but on the computer it is easy to make changes. (April 1983)

The versatility of Logo also made it possible for all students to explore at a level suitable to them. Students could explore in Instant Logo, in the Direct Draw mode, or take advantage of more advanced programming skills. They could also receive pleasing results by embellishing their exploration with colour, or by combining, rotating, or superimposing different shapes or designs. This versatility of Logo is exemplified by the results obtained across all grades by a common challenge of "writing your name or other letters" (Figures 11.9, 11.10, and 11.11). Activities during free-style explorations fell into several categories:

1) those that followed activity cards, examples in manuals or magazines, or used ideas from friends;
2) those that extended or modified a class lesson, a challenge, or an idea from a book (Figures 11.12 and 11.13);
3) those that were new ideas but which were triggered by a classroom activity;
4) those that were drawn from a student's living environment, such as
   a) familiar objects or themes such as faces (Figure 11.14), trucks, cars, animals, birthdays, seasonal events, movies, TV programs, books, playground, and others (Figures 11.15 and 11.16);
   b) video games such as PACMAN (Figure 11.17.), Q.Bert (Figure 11.18), space games (Figures 11.19, 11.20, 11.21, and 11.22).

The judicious blend of direction and free exploration, therefore, helped to develop not only problem-solving strategies but also problem-creating strategies. The computer (Logo) offered an immediate medium for executing and evaluating those strategies.

Figure 11.9

Demonstrating the Versatility of Logo: Examples of Letters, Names and Numbers Done in the Direct Draw Mode by Students of Various Grades

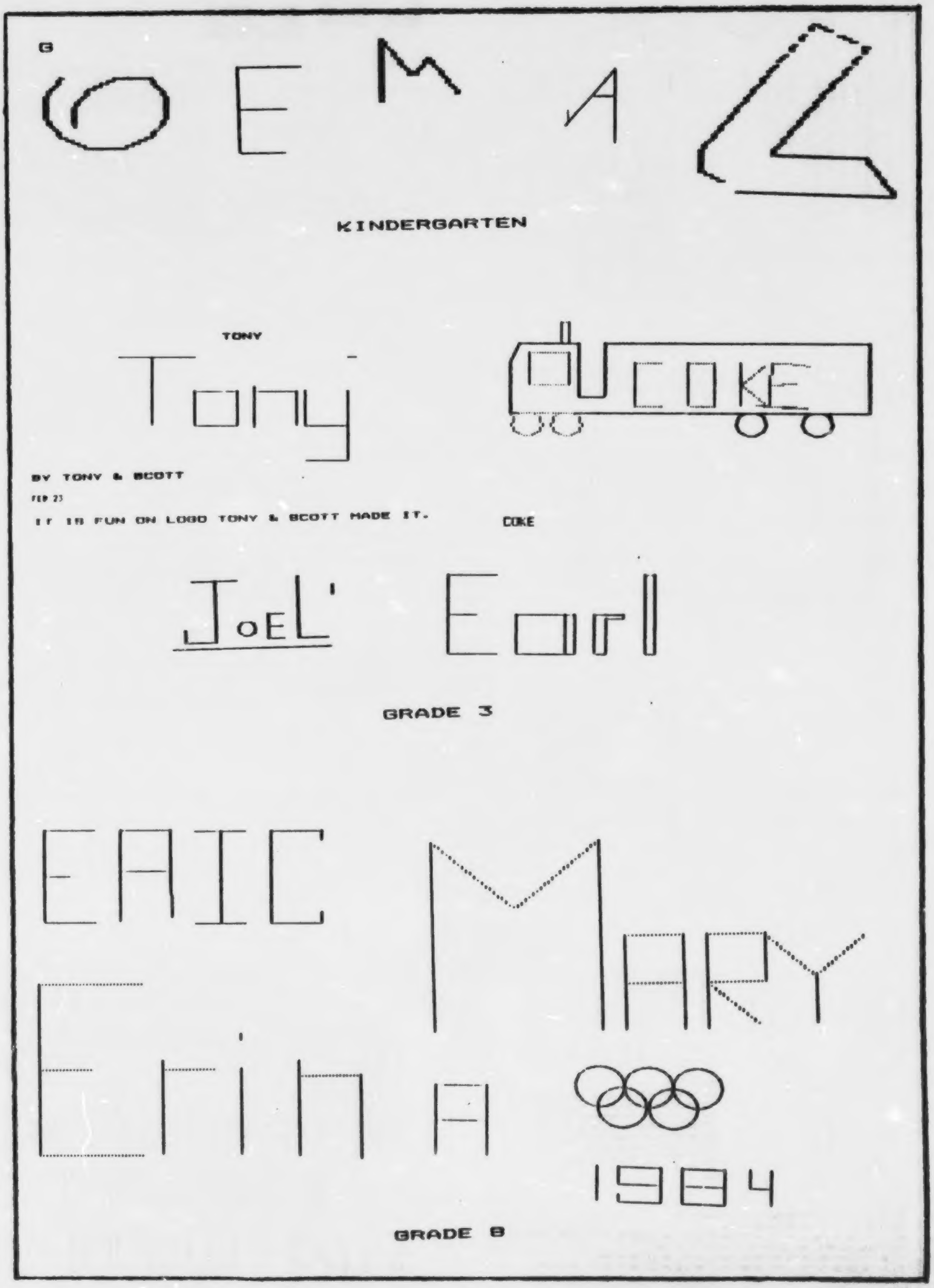
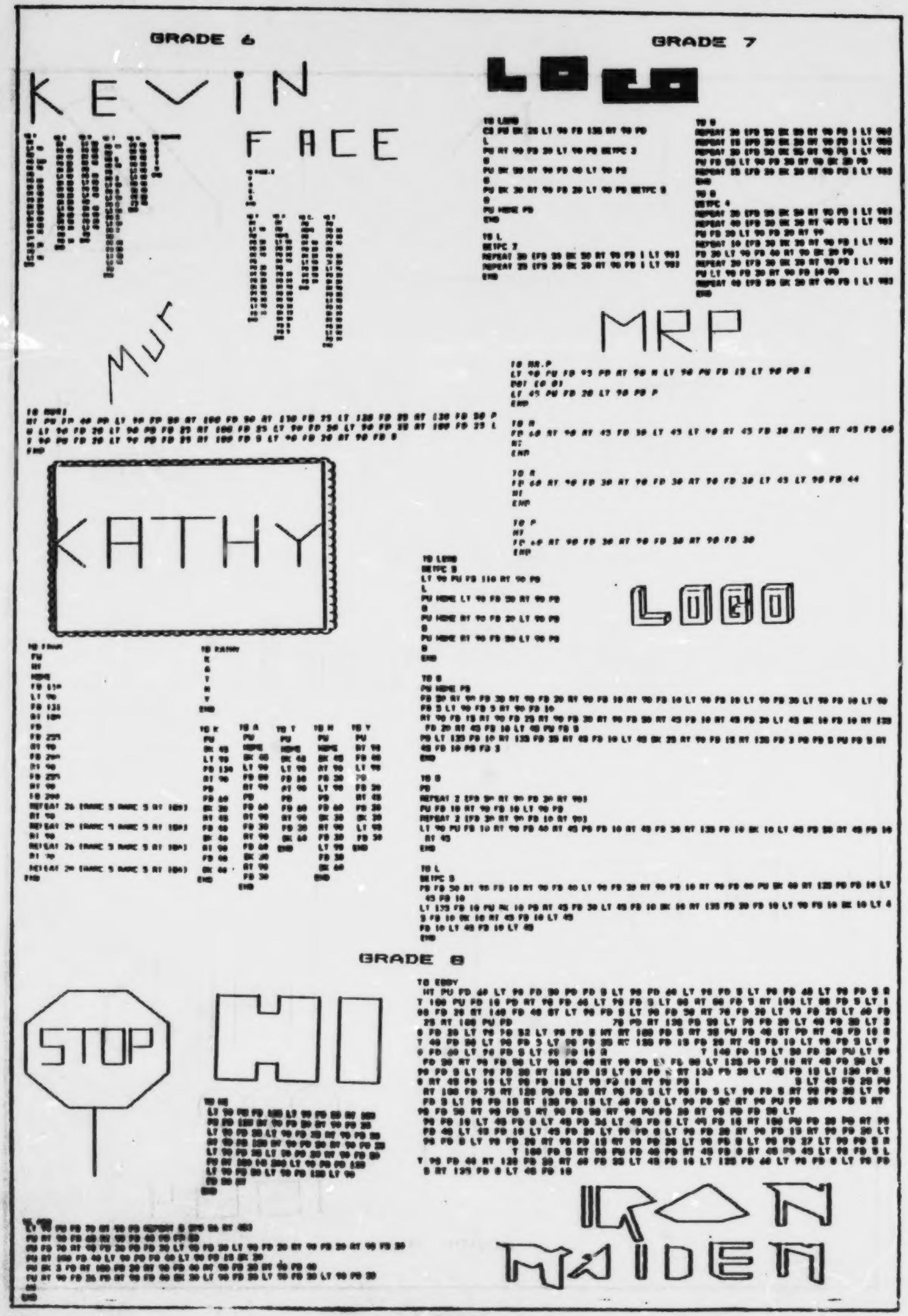

G
O E M A L
KINDERGARTEN
TONY
Tony
COKE
BY TONY & SCOTT
FEB 23
IT IS FUN ON LOGO TONY & SCOTT MADE IT.
COKE
JoEL
Earl
GRADE 3
ERIC
MARY
Erin a
1984
GRADE 8

Figure 11.10

Demonstrating the Versatility of Logo: Examples of Names and Words Done by Students From Various Grades Using Sample Procedures


GRADE 6
GRADE 7
KEVIN
LOGO
FACE
Mur
MRP
KATHY
LOGO
GRADE 8
STOP
HI
IRON
MAIDEN

Figures 11.11

Demonstrating the Versatility of Logo: Examples of Letters and Names Produced by Grade 6 Students Using More Sophisticated Programming Techniques and Extending These to Create Designs With Them

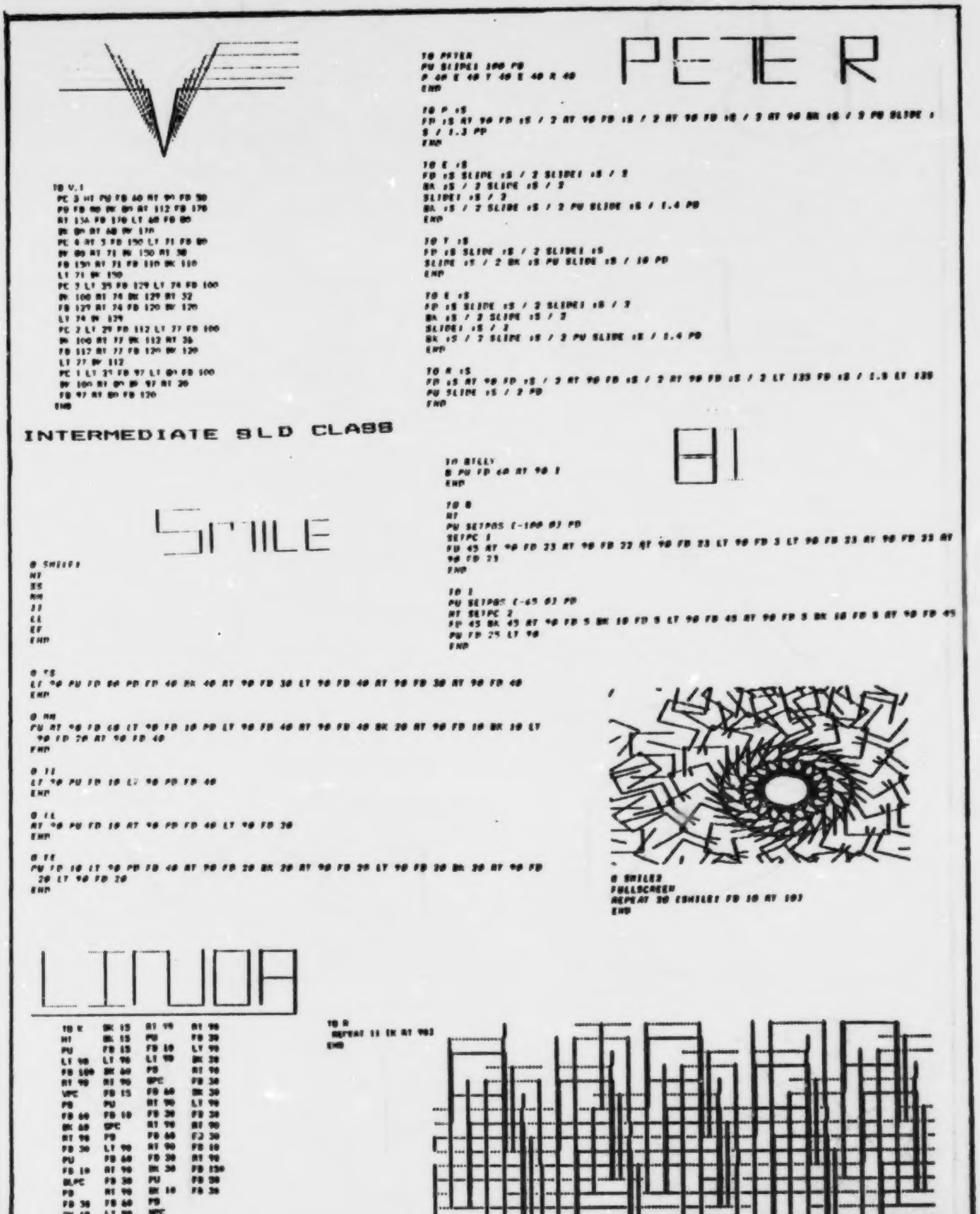

PETER
INTERMEDIATE SLD CLASS
BI
SMILE
LINDA

Figure 11.12

Examples of Free Explorations With Instant Logo

From a Kindergarten Class

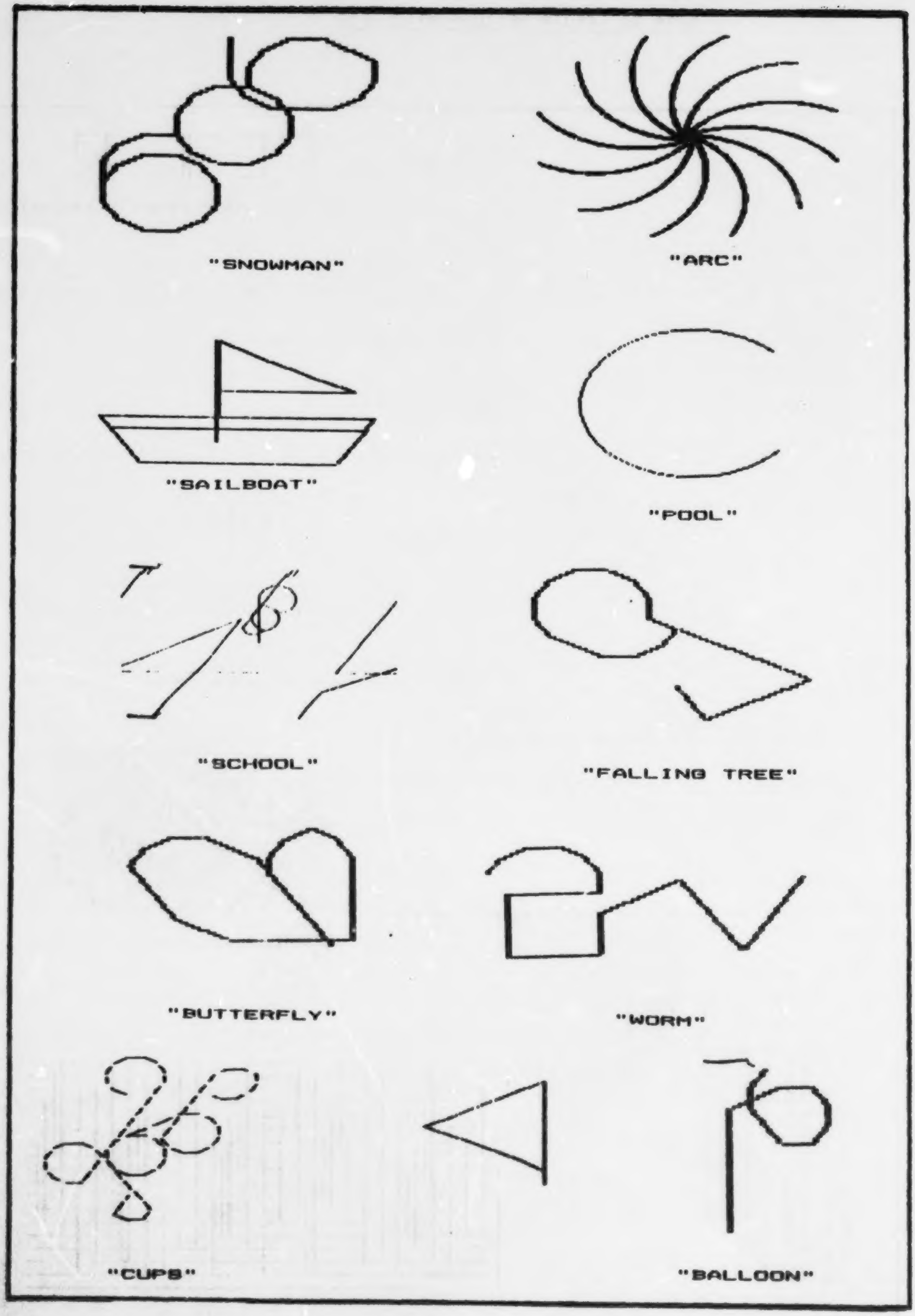
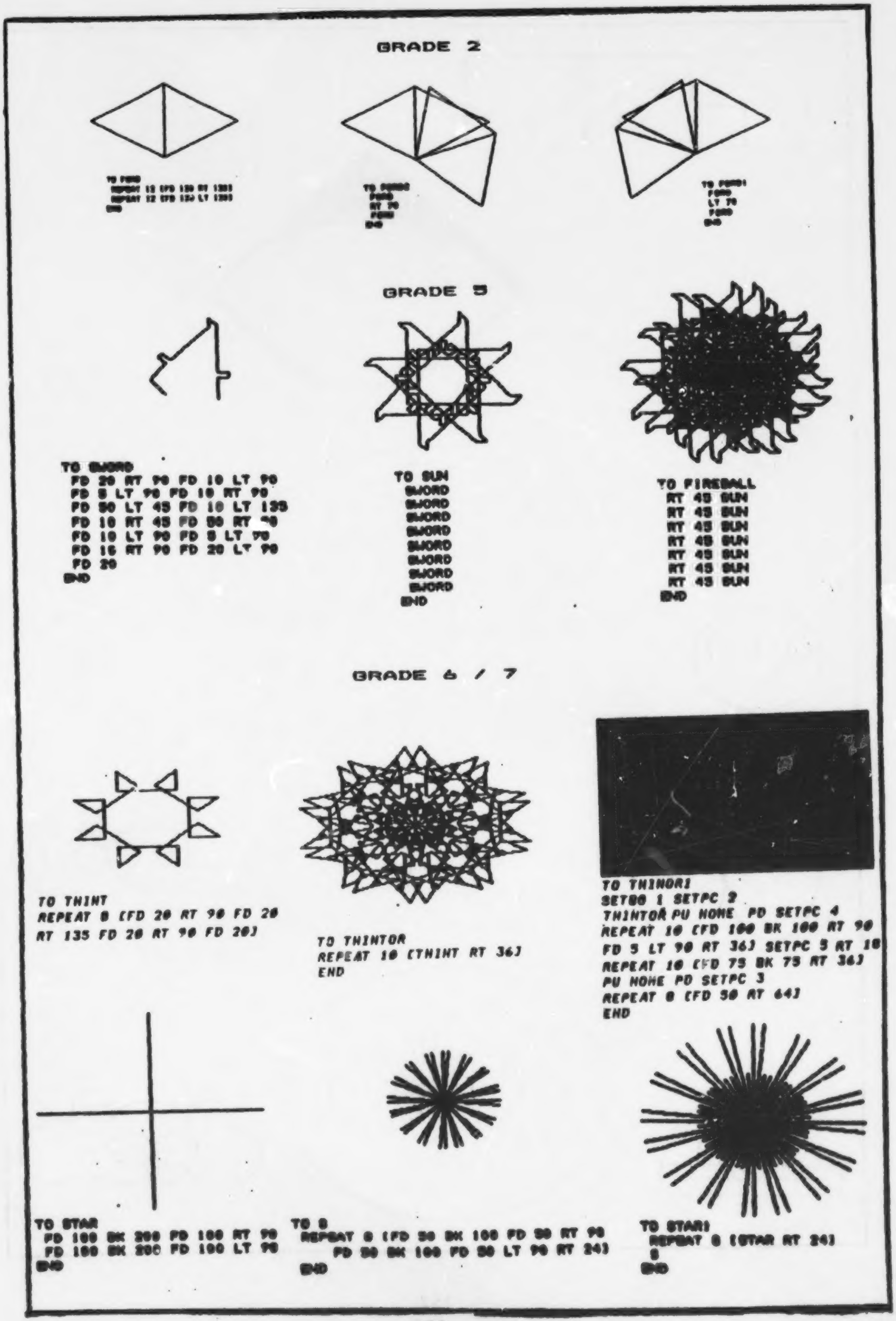

"SNOWMAN"
"ARC"
"SAILBOAT"
"POOL"
"SCHOOL"
"FALLING TREE"
"BUTTERFLY"
"WORM"
"CUPS"
"BALLOON"

Figure 11.13

Examples of Free Explorations Following a Lesson on Modular Programming by a Grade 2, a Grade 5 and two Grade 6/7 Students



```
TO FORD
 REPEAT 12 [FD 120 RT 120]
 REPEAT 12 [FD 120 LT 120]
END
```

```
TO FORD2
 FORD
 RT 70
 FORD
END
```

```
TO FORD1
 FORD
 LT 70
 FORD
END
```

```
TO SWORD
  FD 20 RT 90 FD 10 LT 90
  FD 5 LT 90 FD 10 RT 90
  FD 50 LT 45 FD 10 LT 135
  FD 10 RT 45 FD 50 RT 90
  FD 10 LT 90 FD 5 LT 90
  FD 15 RT 90 FD 20 LT 90
  FD 20
END
```

```
TO SUN
  SWORD
  SWORD
  SWORD
  SWORD
  SWORD
  SWORD
  SWORD
  SWORD
END
```

```
TO FIREBALL
  RT 45 SUN
  RT 45 SUN
  RT 45 SUN
  RT 45 SUN
  RT 45 SUN
  RT 45 SUN
  RT 45 SUN
END
```

```
TO THINT
REPEAT 8 [FD 20 RT 90 FD 20
RT 135 FD 20 RT 90 FD 20]
```

```
TO THINTOR
REPEAT 10 [THINT RT 36]
END
```

```
TO THINORI
SETBG 1 SETPC 2
THINTOR PU HOME  PD SETPC 4
REPEAT 10 [FD 100 BK 100 RT 90
FD 5 LT 90 RT 36] SETPC 5 RT 18
REPEAT 10 [FD 75 BK 75 RT 36]
PU HOME PD SETPC 3
REPEAT 8 [FD 50 RT 64]
END
```

```
TO STAR
 FD 100 BK 200 FD 100 RT 90
 FD 100 BK 200 FD 100 LT 90
END
```

```
TO S
 REPEAT 8 [FD 50 BK 100 FD 50 RT 90
      FD 50 BK 100 FD 50 LT 90 RT 24]
END
```

```
TO STAR1
 REPEAT 8 [STAR RT 24]
 S
END
```

Figure 11.14

Examples of Free Explorations: 'Faces' Drawn by Students From All Grades Using a Variety of Programming Techniques

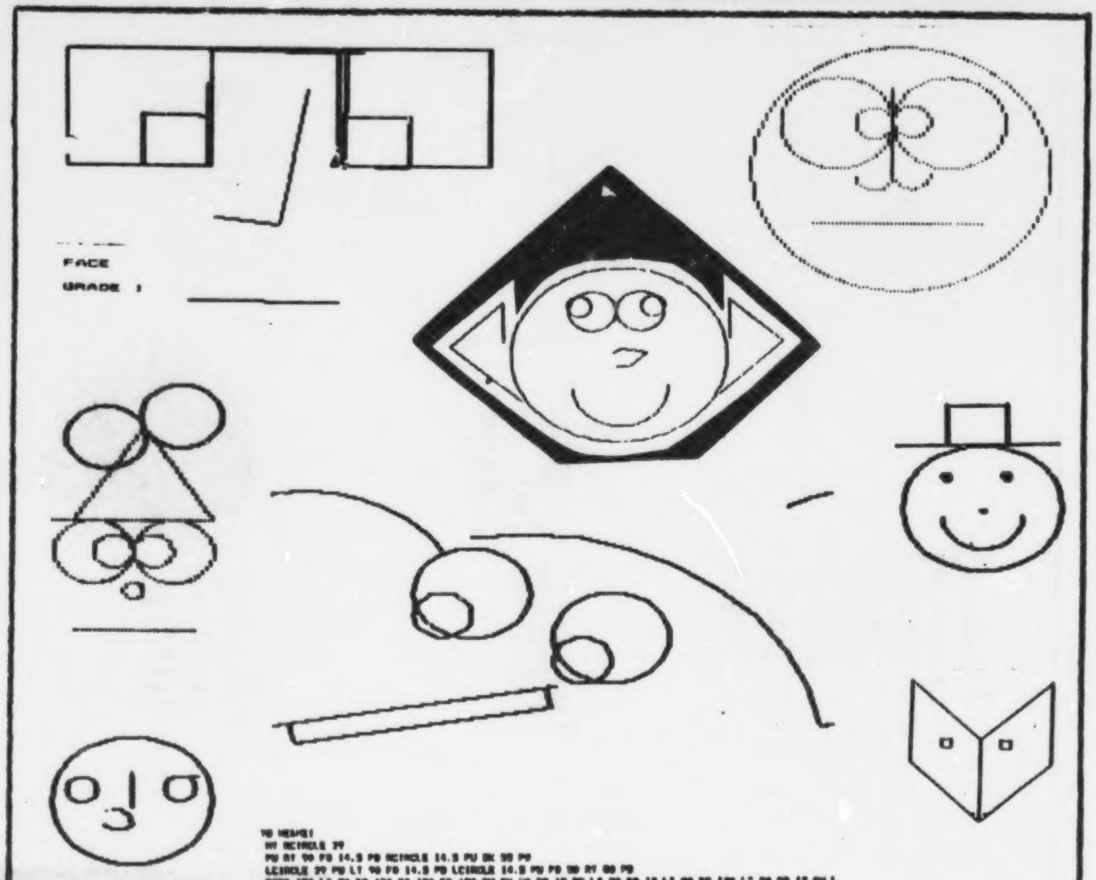


Figure 11.15

Examples of Free Explorations Drawn by Grade 8 Students Using the Direct Draw Mode

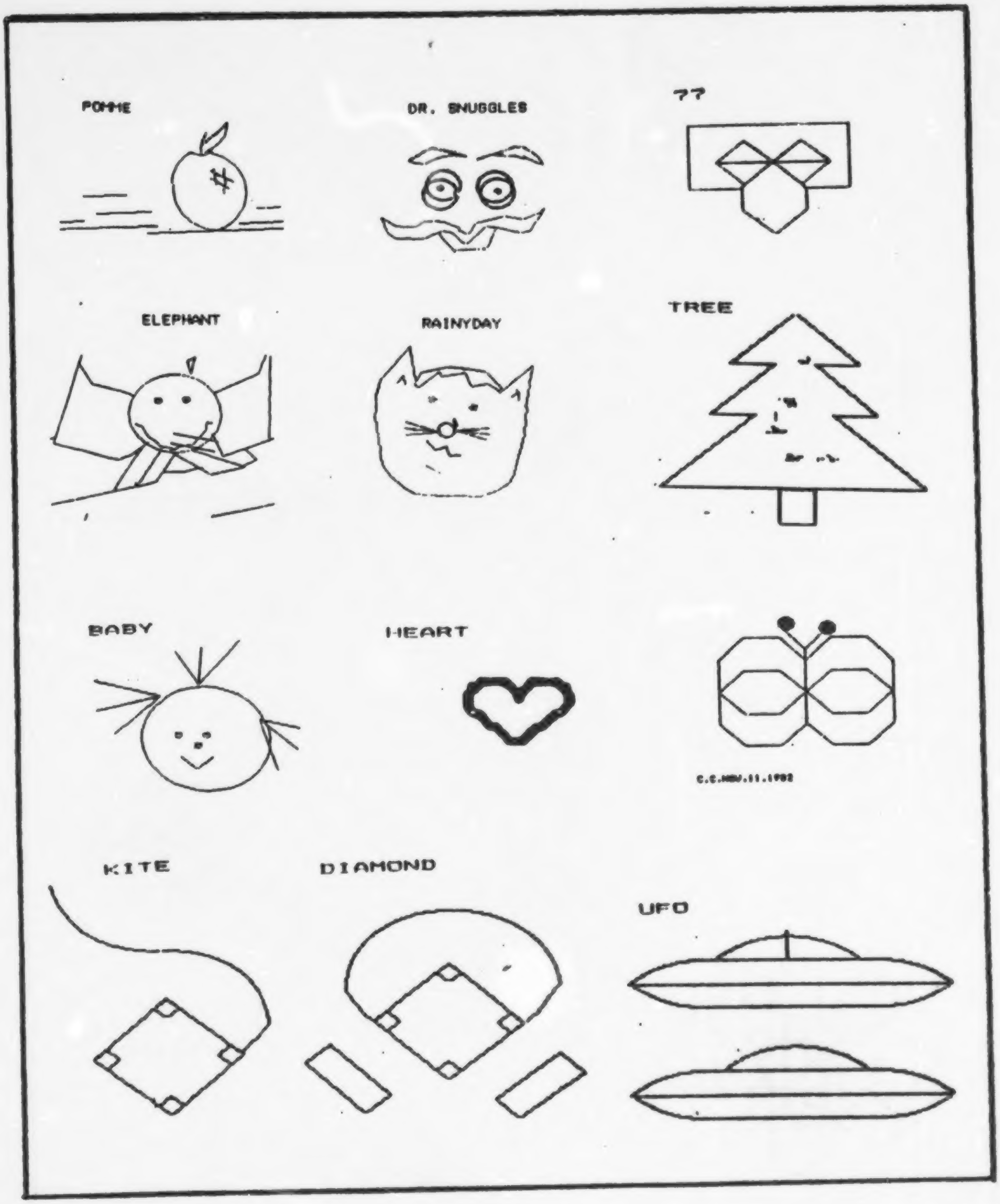

POMME
DR. SNUGGLES
??
ELEPHANT
RAINYDAY
TREE
BABY
HEART
C.C.NOV.11.1982
KITE
DIAMOND
UFO

Figure 11.16

Free Explorations: A Collection of Weapons Drawn by Students in a Grade 6 Class Using a Variety of Programming Techniques

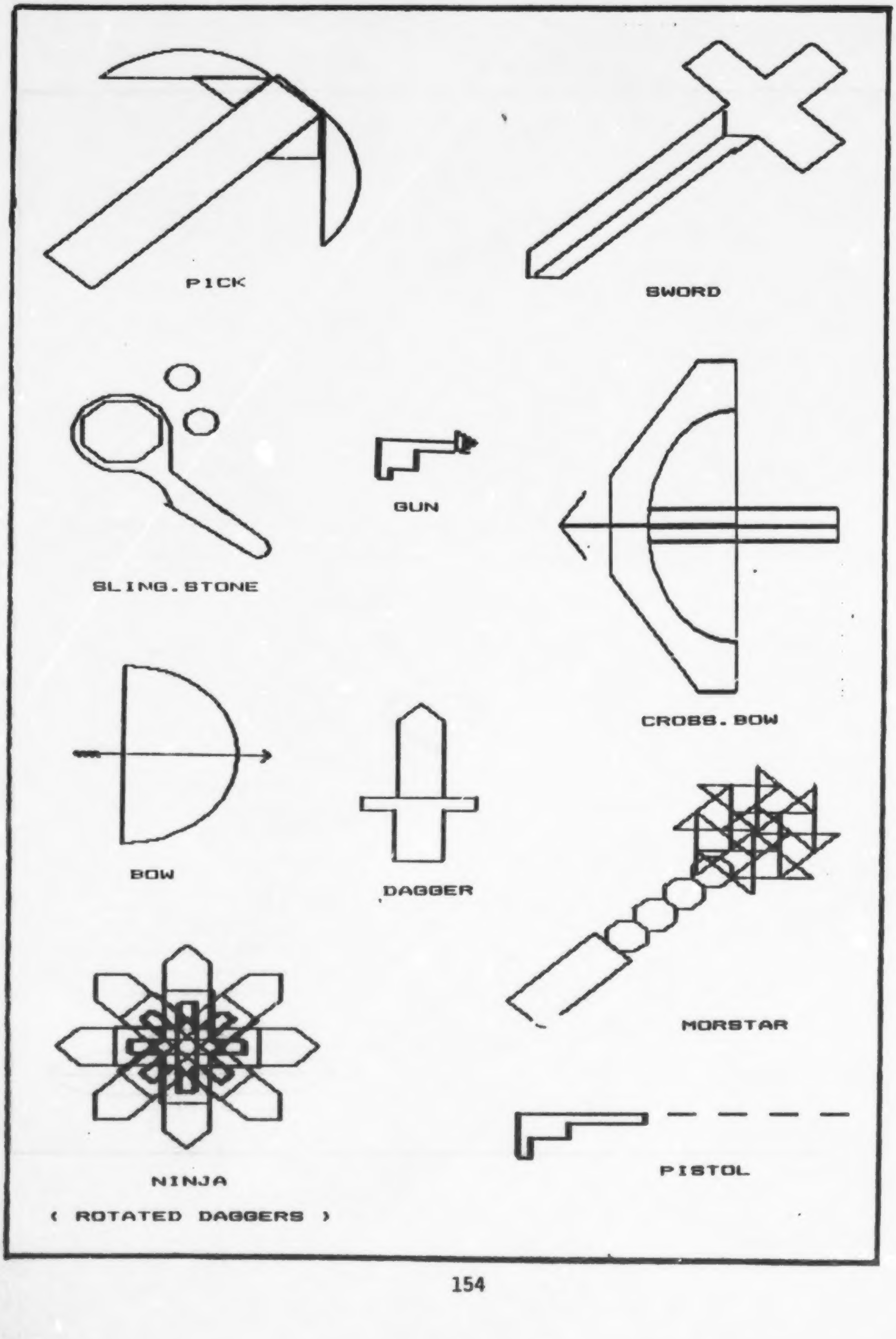
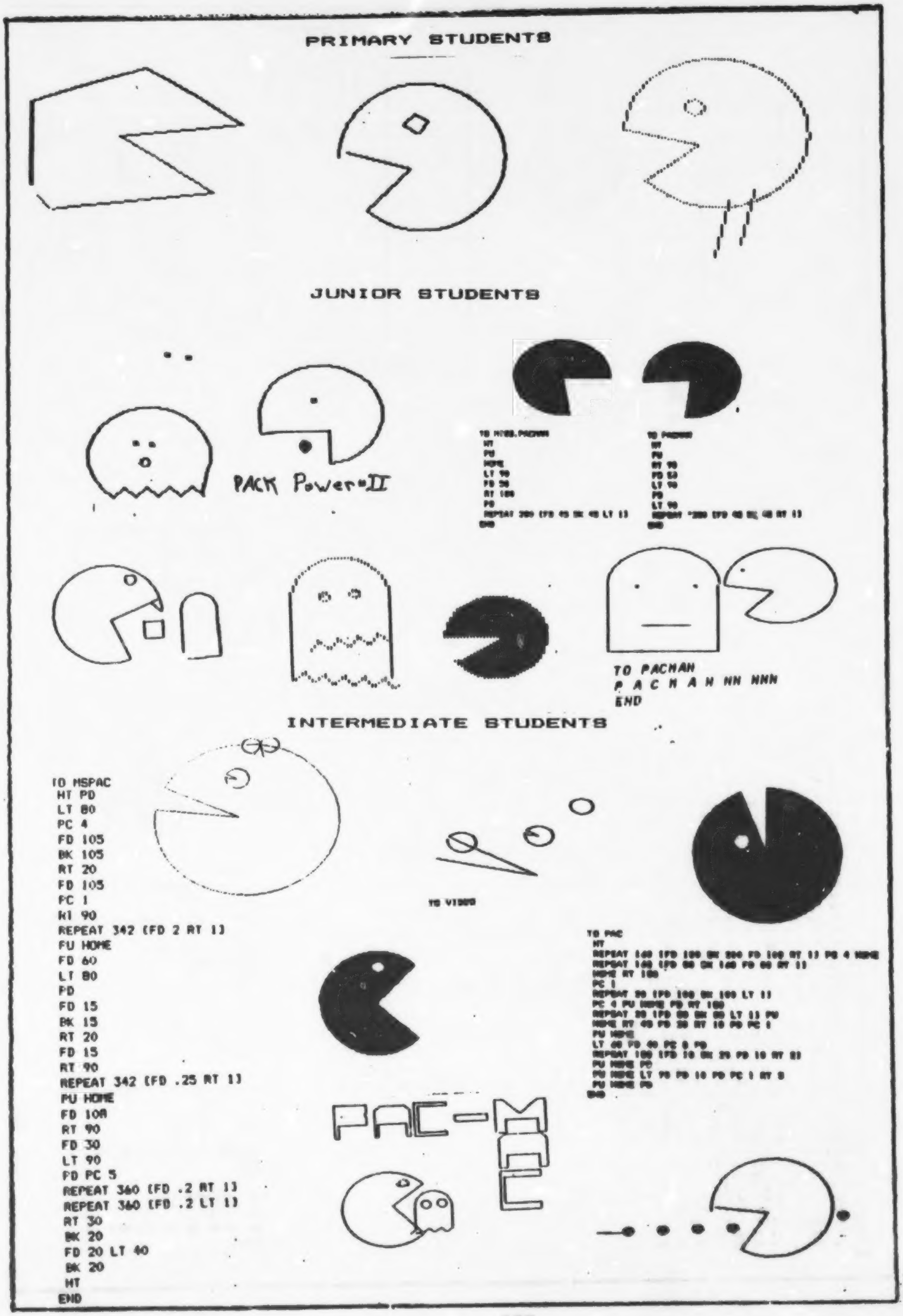

PICK
SWORD
SLING.STONE
GUN
CROSS.BOW
BOW
DAGGER
MORSTAR
NINJA
(ROTATED DAGGERS)
PISTOL

Figure 11.17

Drawing Ideas from the Video Culture: A Collection of 'PACMAN' Pictures Drawn by Students from All Grades Using a Variety of Programming Techniques

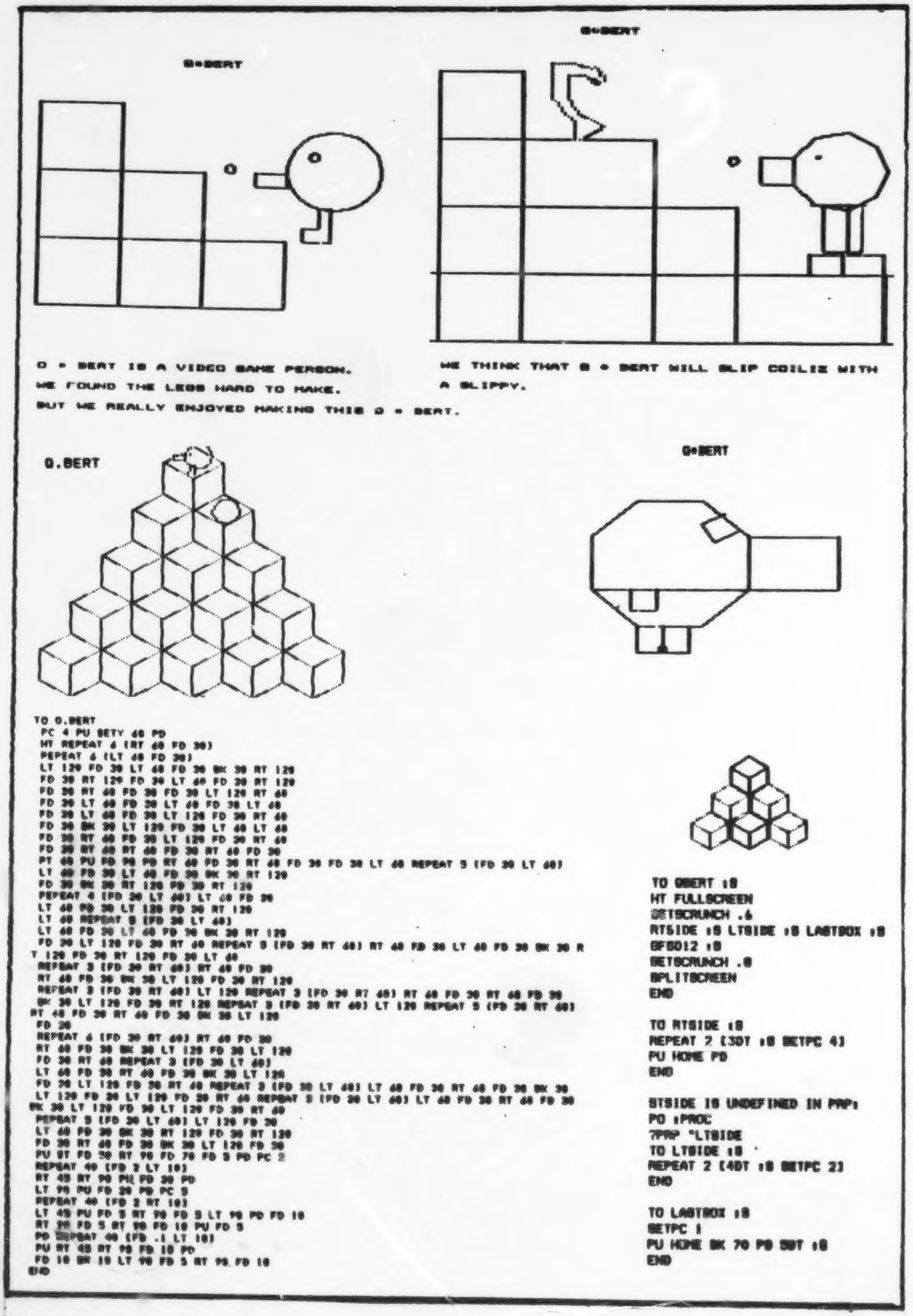

PRIMARY STUDENTS
JUNIOR STUDENTS
PACK Power=II
INTERMEDIATE STUDENTS
TO VIDEO
PAC-MAN

```
TO PACMAN
P A C M A N MN MNN
END
```

```
IO MSPAC
 HT PD
 LT 80
 PC 4
 FD 105
 BK 105
 RT 20
 FD 105
 PC 1
 kI 90
 REPEAT 342 [FD 2 RT 1]
 FU HOME
 FD 60
 LT 80
 PD
 FD 15
 BK 15
 RT 20
 FD 15
 RT 90
 REPEAT 342 [FD .25 RT 1]
 PU HOME
 FD 10A
 RT 90
 FD 30
 LT 90
 PD PC 5
 REPEAT 360 [FD .2 RT 1]
 REPEAT 360 [FD .2 LT 1]
 RT 30
 BK 20
 FD 20 LT 40
 BK 20
 HT
 END
```

Figure 11.18

Drawing Ideas from the Video Culture: Pictures of 'Q.BERT' Produced by Students From Grade 3, 6, and 8



Q * BERT IS A VIDEO GAME PERSON.
WE FOUND THE LEGS HARD TO MAKE.
BUT WE REALLY ENJOYED MAKING THIS Q * BERT.

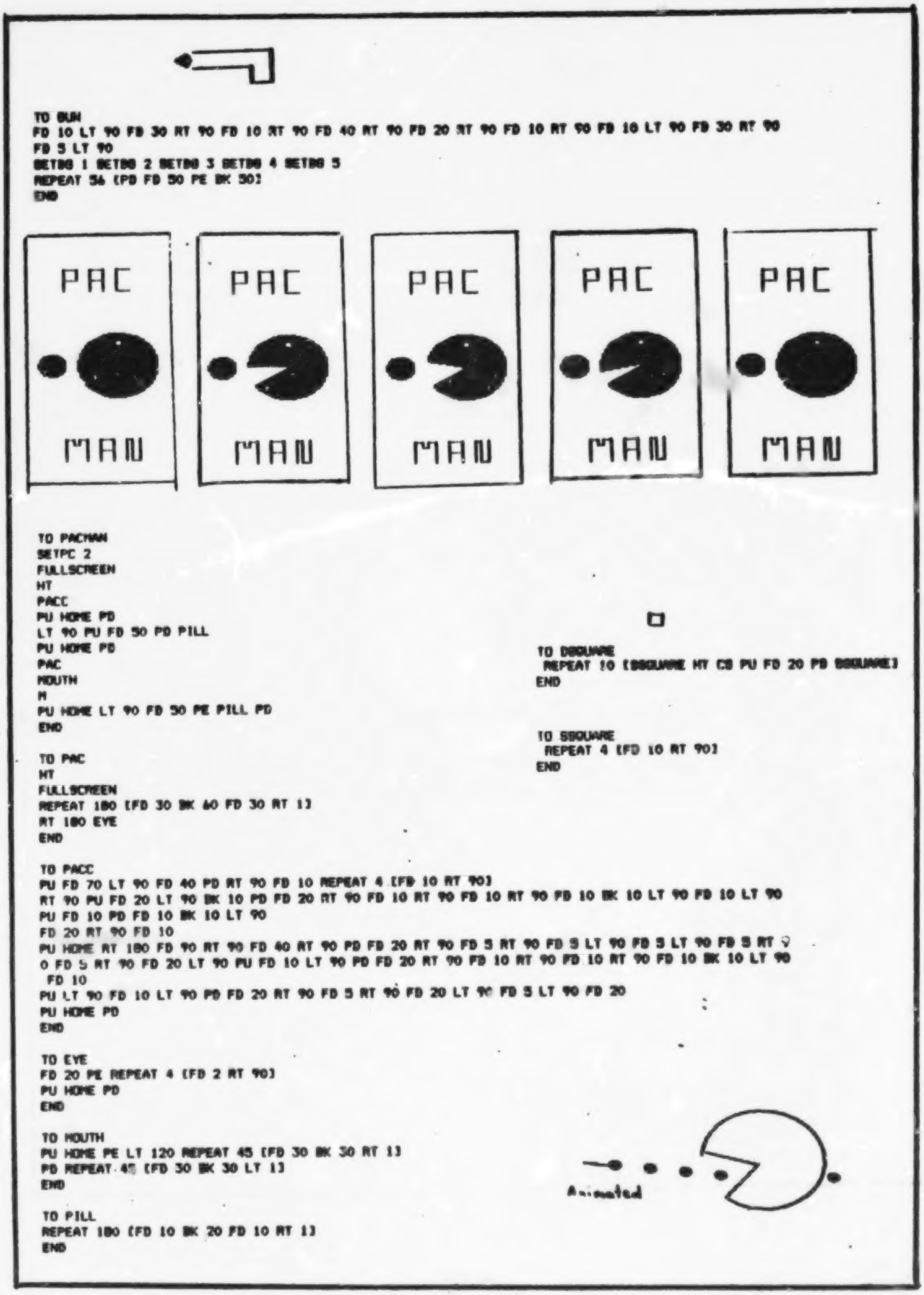
WE THINK THAT Q * BERT WILL SLIP COILIZ WITH
A SLIPPY.

```
TO Q.BERT
 PC 4 PU SETY 60 PD
 HT REPEAT 6 [RT 60 FD 30]
 PEPEAT 6 [LT 60 FD 30]
 LT 120 FD 30 LT 60 FD 30 BK 30 RT 120
 FD 30 RT 120 FD 30 LT 60 FD 30 RT 120
 FD 30 RT 60 FD 30 FD 30 LT 120 RT 60
 FD 30 LT 60 FD 30 LT 60 FD 30 LT 60
 FD 30 LT 60 FD 30 LT 120 FD 30 RT 60
 FD 30 BK 30 LT 120 FD 30 LT 60 LT 60
 FD 30 RT 60 FD 30 LT 120 FD 30 RT 60
 FD 30 RT 60 RT 60 FD 30 RT 60 FD 30
 PT 60 PU FD 90 PD RT 60 FD 30 RT 60 FD 30 FD 30 LT 60 REPEAT 5 [FD 30 LT 60]
 LT 60 FD 30 LT 60 FD 30 BK 30 RT 120
 FD 30 BK 30 RT 120 FD 30 RT 120
 PEPEAT 4 [FD 30 LT 60] LT 60 FD 30
 LT 60 FD 30 LT 120 FD 30 RT 120
 LT 60 REPEAT 5 [FD 30 LT 60]
 LT 60 FD 30 LT 60 FD 30 BK 30 RT 120
 FD 30 LT 120 FD 30 RT 60 REPEAT 3 [FD 30 RT 60] RT 60 FD 30 LT 60 FD 30 BK 30 R
T 120 FD 30 RT 120 FD 30 LT 60
 REPEAT 3 [FD 30 RT 60] RT 60 FD 30
 RT 60 FD 30 BK 30 LT 120 FD 30 RT 120
 REPEAT 3 [FD 30 RT 60] LT 120 REPEAT 3 [FD 30 RT 60] RT 60 FD 30 RT 60 FD 30
 BK 30 LT 120 FD 30 RT 120 REPEAT 3 [FD 30 RT 60] LT 120 REPEAT 5 [FD 30 RT 60]
RT 60 FD 30 RT 60 FD 30 BK 30 LT 120
 FD 30
 REPEAT 6 [FD 30 RT 60] RT 60 FD 30
 RT 60 FD 30 BK 30 LT 120 FD 30 LT 120
 FD 30 RT 60 REPEAT 3 [FD 30 LT 60]
 LT 60 FD 30 RT 60 FD 30 BK 30 LT 120
 FD 30 LT 120 FD 30 RT 60 REPEAT 3 [FD 30 LT 60] LT 60 FD 30 RT 60 FD 30 BK 30
 LT 120 FD 30 LT 120 FD 30 RT 60 REPEAT 3 [FD 30 LT 60] LT 60 FD 30 RT 60 FD 30
BK 30 LT 120 FD 30 LT 120 FD 30 RT 60
 PEPEAT 5 [FD 30 LT 60] LT 120 FD 30
 LT 60 FD 30 BK 30 RT 120 FD 30 RT 120
 FD 30 RT 60 FD 30 BK 30 LT 120 FD 30
 PU ST FD 50 RT 90 FD 70 FD 5 PD PC 2
 REPEAT 40 [FD 2 LT 10]
 RT 45 RT 90 PU FD 30 PD
 LT 90 PU FD 20 PD PC 5
 REPEAT 40 [FD 2 RT 10]
 LT 45 PU FD 5 RT 90 FD 5 LT 90 PD FD 10
 RT 90 FD 5 RT 90 FD 10 PU FD 5
 PD REPEAT 40 [FD .1 LT 10]
 PU RT 45 RT 90 FD 10 PD
 FD 10 BK 10 LT 90 FD 5 RT 90. FD 10
END
```

```
TO QBERT :S
HT FULLSCREEN
SETSCRUNCH .6
RTSIDE :S LTSIDE :S LASTBOX :S
BFSD12 :S
SETSCRUNCH .8
SPLITSCREEN
END

TO RTSIDE :S
REPEAT 2 [3DT :S SETPC 4]
PU HOME PD
END

STSIDE IS UNDEFINED IN PRP:
PO :PROC
?PRP "LTSIDE
TO LTSIDE :S
REPEAT 2 [4DT :S SETPC 2]
END

TO LASTBOX :S
SETPC 1
PU HOME BK 70 PD 5DT :S
END
```

Figure 11.19

Examples of Early Attempts at Animation by Junior- and Intermediate-Level Students



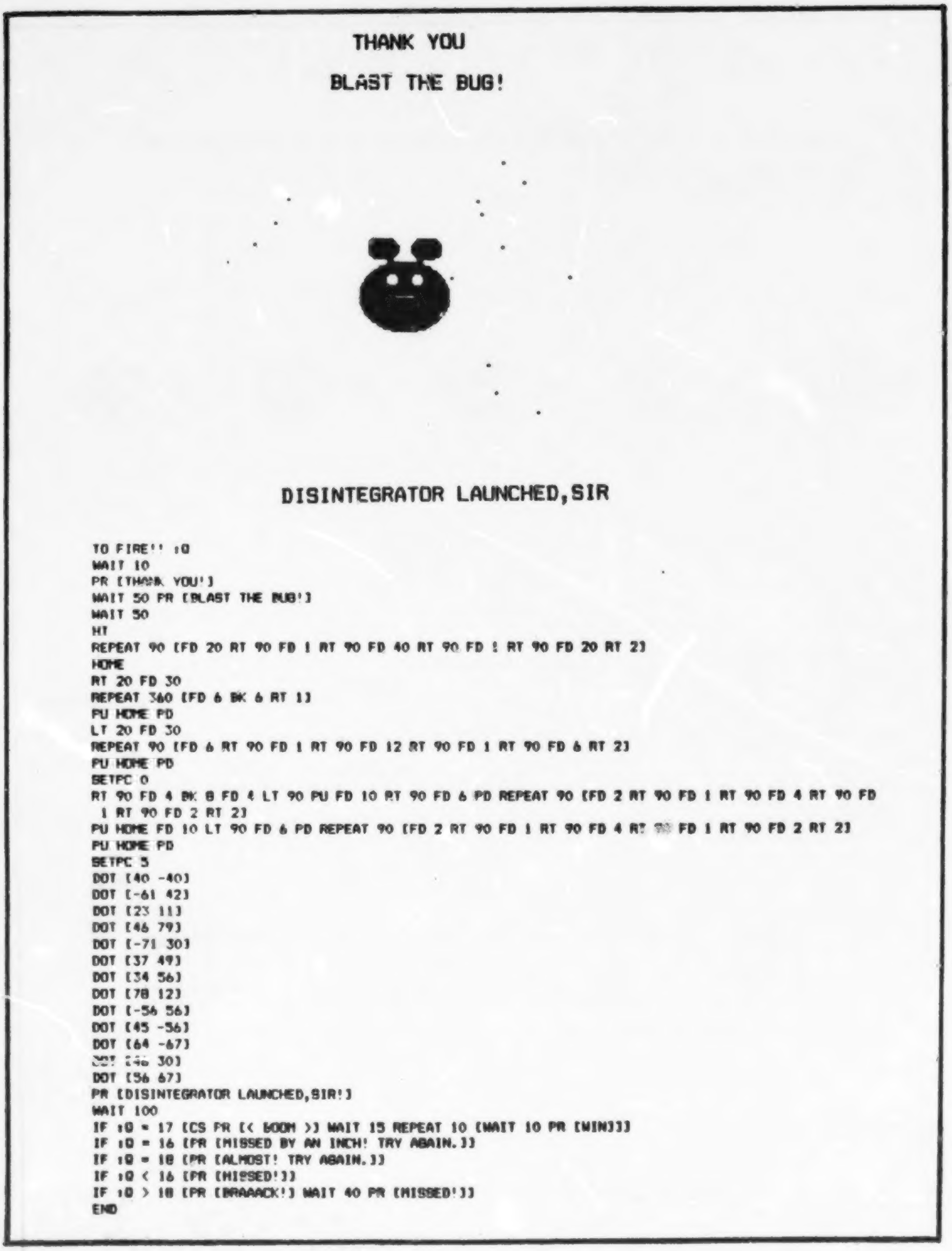
```
TO GUN
FD 10 LT 90 FD 30 RT 90 FD 10 RT 90 FD 40 RT 90 FD 20 RT 90 FD 10 RT 90 FD 10 LT 90 FD 30 RT 90
FD 5 LT 90
SETBG 1 SETBG 2 SETBG 3 SETBG 4 SETBG 5
REPEAT 56 [PD FD 50 PE BK 50]
END
```

```
TO PACMAN
SETPC 2
FULLSCREEN
HT
PACC
PU HOME PD
LT 90 PU FD 50 PD PILL
PU HOME PD
PAC
MOUTH
M
PU HOME LT 90 FD 50 PE PILL PD
END

TO PAC
HT
FULLSCREEN
REPEAT 180 [FD 30 BK 60 FD 30 RT 1]
RT 180 EYE
END

TO PACC
PU FD 70 LT 90 FD 40 PD RT 90 FD 10 REPEAT 4 [FD 10 RT 90]
RT 90 PU FD 20 LT 90 BK 10 PD FD 20 RT 90 FD 10 RT 90 FD 10 RT 90 FD 10 BK 10 LT 90 FD 10 LT 90
PU FD 10 PD FD 10 BK 10 LT 90
FD 20 RT 90 FD 10
PU HOME RT 180 FD 90 RT 90 FD 40 RT 90 PD FD 20 RT 90 FD 5 RT 90 FD 5 LT 90 FD 5 LT 90 FD 5 RT 9
0 FD 5 RT 90 FD 20 LT 90 PU FD 10 LT 90 PD FD 20 RT 90 FD 10 RT 90 FD 10 RT 90 FD 10 BK 10 LT 90
 FD 10
PU LT 90 FD 10 LT 90 PD FD 20 RT 90 FD 5 RT 90 FD 20 LT 90 FD 5 LT 90 FD 20
PU HOME PD
END

TO EYE
FD 20 PE REPEAT 4 [FD 2 RT 90]
PU HOME PD
END

TO MOUTH
PU HOME PE LT 120 REPEAT 45 [FD 30 BK 30 RT 1]
PD REPEAT 45 [FD 30 BK 30 LT 1]
END

TO PILL
REPEAT 180 [FD 10 BK 20 FD 10 RT 1]
END
```

```
TO DSQUARE
 REPEAT 10 [SSQUARE HT CS PU FD 20 PD SSQUARE]
END

TO SSQUARE
 REPEAT 4 [FD 10 RT 90]
END
```

Figure 11.20

An Example of A Game Designed by Two Grade 6 Students



THANK YOU

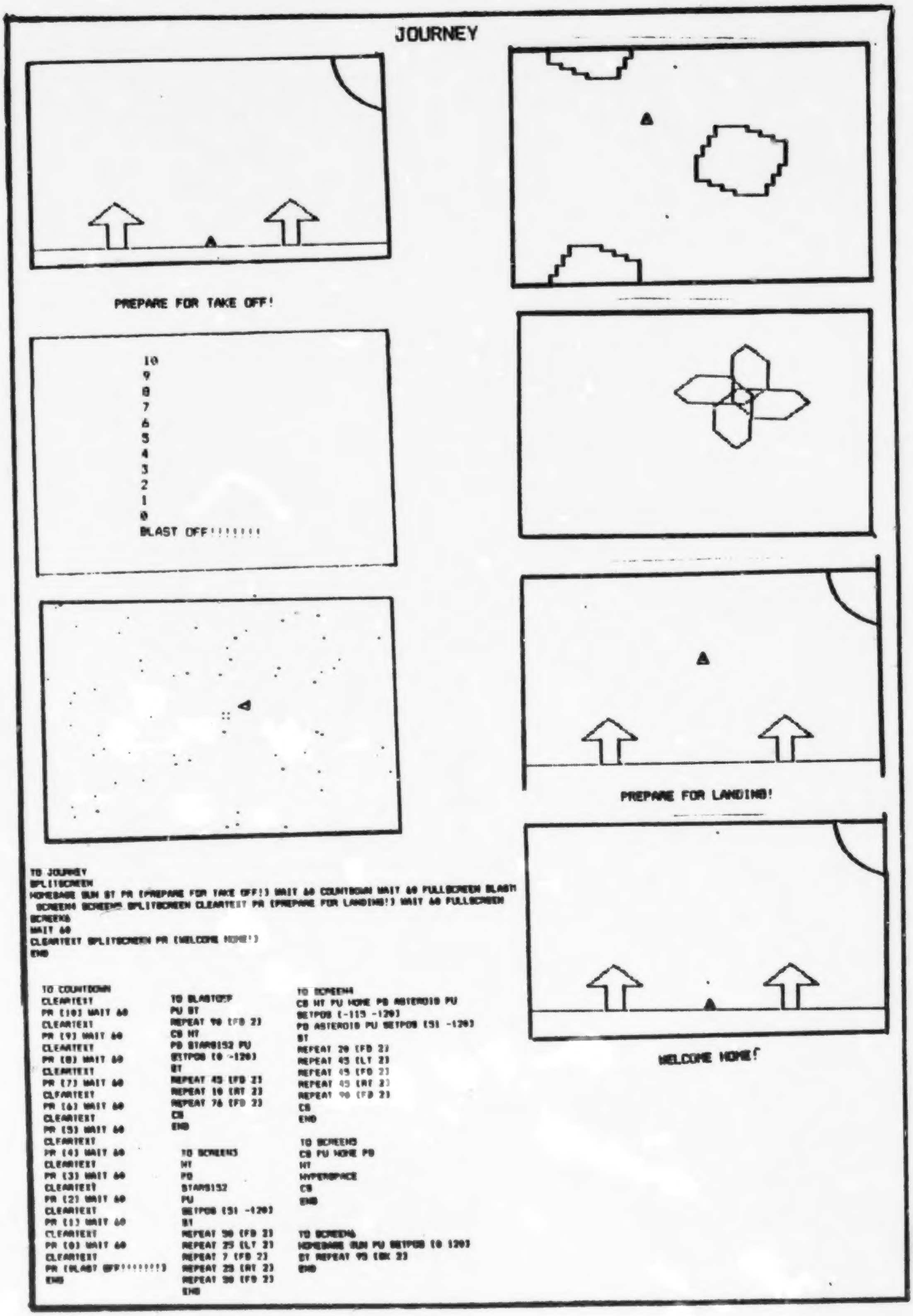
BLAST THE BUG!

DISINTEGRATOR LAUNCHED,SIR

```
TO FIRE!! :Q
WAIT 10
PR [THANK YOU!]
WAIT 50 PR [BLAST THE BUG!]
WAIT 50
HT
REPEAT 90 [FD 20 RT 90 FD 1 RT 90 FD 40 RT 90 FD 1 RT 90 FD 20 RT 2]
HOME
RT 20 FD 30
REPEAT 360 [FD 6 BK 6 RT 1]
PU HOME PD
LT 20 FD 30
REPEAT 90 [FD 6 RT 90 FD 1 RT 90 FD 12 RT 90 FD 1 RT 90 FD 6 RT 2]
PU HOME PD
SETPC 0
RT 90 FD 4 BK 8 FD 4 LT 90 PU FD 10 RT 90 FD 6 PD REPEAT 90 [FD 2 RT 90 FD 1 RT 90 FD 4 RT 90 FD
 1 RT 90 FD 2 RT 2]
PU HOME FD 10 LT 90 FD 6 PD REPEAT 90 [FD 2 RT 90 FD 1 RT 90 FD 4 RT 90 FD 1 RT 90 FD 2 RT 2]
PU HOME PD
SETPC 5
DOT [40 -40]
DOT [-61 42]
DOT [23 11]
DOT [46 79]
DOT [-71 30]
DOT [37 49]
DOT [34 56]
DOT [78 12]
DOT [-56 56]
DOT [45 -56]
DOT [64 -67]
DOT [46 30]
DOT [56 67]
PR [DISINTEGRATOR LAUNCHED,SIR!]
WAIT 100
IF :Q = 17 [CS PR [< BOOM >] WAIT 15 REPEAT 10 [WAIT 10 PR [WIN]]]
IF :Q = 16 [PR [MISSED BY AN INCH! TRY AGAIN.]]
IF :Q = 18 [PR [ALMOST! TRY AGAIN.]]
IF :Q < 16 [PR [MISSED!]]
IF :Q > 18 [PR [BRAAACK!] WAIT 40 PR [MISSED!]]
END
```

Figure 11.21

'JOURNEY': A Pictorial Story of the 'Turtle' Travelling Through Space Designed by Two Grade 7 Students



PREPARE FOR TAKE OFF!

```
10
9
8
7
6
5
4
3
2
1
0
BLAST OFF!!!!!!!
```

PREPARE FOR LANDING!

WELCOME HOME!

```
TO JOURNEY
SPLITSCREEN
HOMEBASE SUN ST PR [PREPARE FOR TAKE OFF!] WAIT 60 COUNTDOWN WAIT 60 FULLSCREEN BLASTOFF
 SCREEN4 SCREEN5 SPLITSCREEN CLEARTEXT PR [PREPARE FOR LANDING!] WAIT 60 FULLSCREEN
SCREEN6
WAIT 60
CLEARTEXT SPLITSCREEN PR [WELCOME HOME!]
END
```

```
TO COUNTDOWN
CLEARTEXT
PR [10] WAIT 60
CLEARTEXT
PR [9] WAIT 60
CLEARTEXT
PR [8] WAIT 60
CLEARTEXT
PR [7] WAIT 60
CLEARTEXT
PR [6] WAIT 60
CLEARTEXT
PR [5] WAIT 60
CLEARTEXT
PR [4] WAIT 60
CLEARTEXT
PR [3] WAIT 60
CLEARTEXT
PR [2] WAIT 60
CLEARTEXT
PR [1] WAIT 60
CLEARTEXT
PR [0] WAIT 60
CLEARTEXT
PR [BLAST OFF!!!!!!!!]
END
```

```
TO BLASTOFF
PU ST
REPEAT 90 [FD 2]
CS HT
PD STARS152 PU
SETPOS [0 -120]
ST
REPEAT 45 [FD 2]
REPEAT 10 [RT 2]
REPEAT 76 [FD 2]
CS
END
```

```
TO SCREEN3
HT
PD
STARS152
PU
SETPOS [51 -120]
ST
REPEAT 50 [FD 2]
REPEAT 25 [LT 2]
REPEAT 7 [FD 2]
REPEAT 25 [RT 2]
REPEAT 50 [FD 2]
END
```

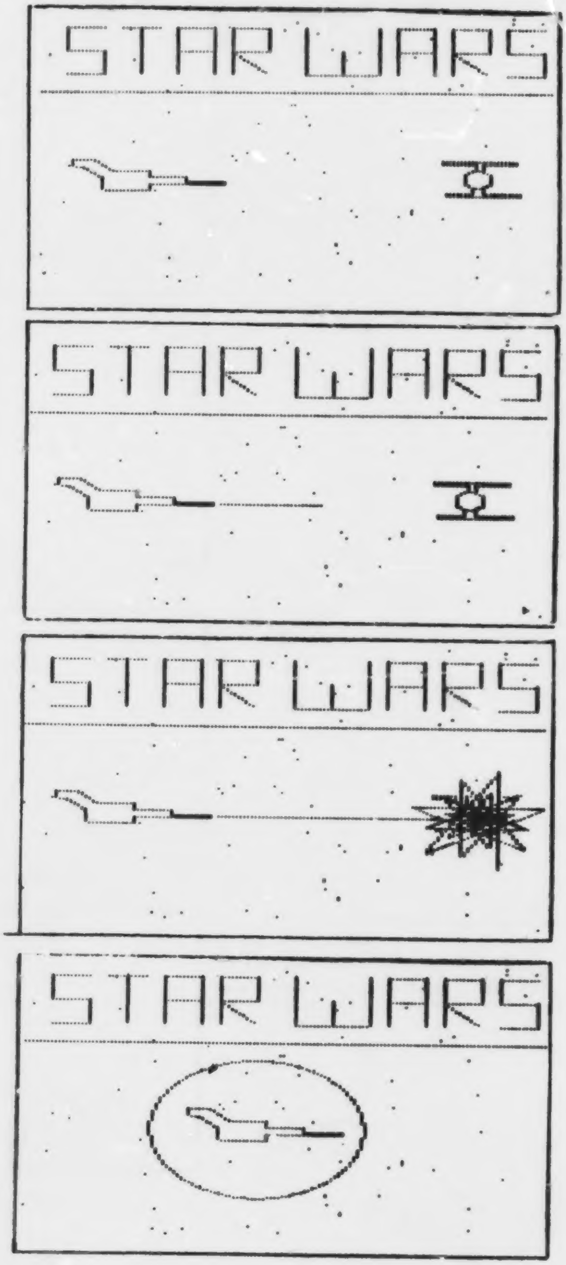
```
TO SCREEN4
CS HT PU HOME PD ASTEROID PU
SETPOS [-115 -120]
PD ASTEROID PU SETPOS [51 -120]
ST
REPEAT 20 [FD 2]
REPEAT 45 [LT 2]
REPEAT 45 [FD 2]
REPEAT 45 [RT 2]
REPEAT 90 [FD 2]
CS
END
```

```
TO SCREEN5
CS PU HOME PD
HT
HYPERSPACE
CS
END
```

```
TO SCREEN6
HOMEBASE SUN PU SETPOS [0 120]
ST REPEAT 95 [BK 2]
END
```

Figure 11.22

'STARWARS': A Pictorial Story Showing The Destruction of One Spaceship by Another Designed by a Grade 8 Student


STAR WARS
STAR WARS
STAR WARS
STAR WARS

```
TO STAR.WARS
  HT
  PRINT ["STAR WARS" DONE BY LEN EVANS]
  GALAXY FULLSCREEN PU
  HOME RT 90 BK 120
  PD
  SHIP
  TIE
  STAR.
  PU
  HOME
  BK 20 RT 90 BK 35
  PD
  REPEAT 13.7 [FD 5 FD 5] PC 4 EXP.LEN
  REPEAT 15 [FD 0] DRAW
  REPEAT 3 [PR []]
  PHASE.TWO
END
```

TEACHER-INITIATED EXPLORATIONS

Finding the appropriate level of instruction or challenge was not always easy and was often obtained after some trial and error. This was true at all grade levels, but particularly so in the lower grades. All students began their initial explorations with FD, BK, LT, RT, PU, and PD. However, Kindergarten students found even this to be too confusing since they had great difficulty finding the appropriate keys on the keyboard. The students also needed some time to comprehend that the action on the keyboard caused things to happen on the monitor screen. Many of the students found this quite puzzling at the outset. Several of them also did not have the ability to recognize letters, nor did they have enough of a number concept that they could use numbers in a purposeful way. Many knew that a two digit number was larger than a one digit number, but they didn't know, for instance, whether 24 was greater or smaller than 42. The teacher eventually used Instant Logo, available on the Terrapin utility disk, which greatly improved students' ability to function on the computer. Towards the end of the year, Kindergarten students were able to use Instant Logo with reasonable ease, "boot" the machine with Logo, and load the Instant and "graphic dump" programs.

Students from Grade 1 and up were all able to use standard Logo. The earliest "directions" by teachers were to set limits on the numeric input that students could use with the FD, BK, LT and RT commands, or to encourage students to stay within the dimensions of the video screen so that they would gain some understanding of and "control" over the turtle's behaviour. Another popular and effective form of direction at the primary and junior-level was given in the form of complete or partial instructions or a number of designs, written on laminated cards. Some examples of such cards in a Grade 1 class are presented in Figure 11.23. One teacher at the junior/intermediate-level, placed "Apple" challenges which students could use on the bulletin board. A few examples of initial challenges that were given to students in a Grade 6/7 class are given in Figure 11.24. One Grade 1 teacher also experimented by using pre-designed shapes like a group of four houses, a pumpkin, a ghost (which was designed by one of the students in the class), and a Christmas tree which students could read from the disk (Figure 11.25). Students were then asked to connect the houses or to fill in the details on the other shapes. Some results of this approach are presented in Figures 11.26 and 11.27.

Additional directions were given by teachers through direct class lessons. For example, one Grade 1 teacher asked her students to write the following instructions in their notebooks:

```
FD __
RT 90
FD __
RT 90
FD __
RT 90
FD __
RT 90
```

and the "formulae" for a circle:

```
REPEAT 90 [RT 4 FD __]
```

for stairs:

```
REPEAT 4 [FD 20 RT 90 FD 20 LT 90]
```

and for a triangle:

```
REPEAT 3 [FD __ RT 120].
```

Similar procedures were offered by the Grade 3 and Grade 5 teachers. Students were then encouraged to experiment by making bigger and smaller squares, circles, and triangles to combine them to make interesting designs (Figures 11.28, 11.29 and 11.30), and animals or creatures (Figures 11.31 and 11.32). The Grade 3 teacher followed this with a lesson on polygons (Figure 11.33) and a lesson on the use of variables (Figure 11.34).

At the intermediate-level, such geometric challenges were extended to "centre a group of squares on the screen" (Figure 11.35), to making bar graphs (which was further extended to making a checkerboard), and to making a filled circle, which also was extended to making a pie graph. Very few students attempted the bar graph or checkerboard challenge; however, one student used the idea to design a Swiss emblem which ignited the imagination of another student in the class, who made the U.S. national flag. Others liked the idea and a series of national flags emerged (Figure 11.36), which further led one student to draw the provinces of Canada complete with appropriate statistics (Figure 11.37). The pie graph challenge led to a variety of approaches (Figure 11.38) and generated another ripple effect in the class. Students created pizzas (Figure 11.39) and balloons (Figure 11.40), some of which were combined with text to give cooking instructions, or to give details for an upcoming class party. An intermediate-level teacher gave his students a picture of a "tessellated" man and the outline of a cat, and challenged them to write procedures in Logo for them. This challenge created great excitement and spread beyond the class to another intermediate-level class in the project. Examples of responses to these challenges, indicating the range of programming approaches, are given in Figures 11.41 and 11.42. A class lesson on variables by a junior-level teacher led to the challenge of making a landscape. This generated a great deal of interaction among students and ideas and suggestions flowed among them.

The teacher reported that:

> Landscape designing going at full tilt. In a show of hands, all (or nearly all) wanted and/or were trying to work on a landscape design. Suns, mountains, trees and buildings are emerging. Kids are giving more demonstrations as they debug their landscapes. These are most often accompanied by discussions and explanations lately. Ian and Steve demonstrated to the class how to make a sun to fit into a landscape. Others demonstrated how their procedures worked. Some landscapes had several printings, one on top of the other. This achieved a kind of surrealistic effect. (March 10/83)

A few examples of their results are presented in Figure 11.43.

A challenge that was given by teachers at all grade levels was that of drawing a house. The responses to this challenge clearly demonstrate the versatility of Logo and its open-ended nature: the challenge to make a house engaged Kindergarten students with Instant Logo; had Grade 1 students explore with Instant Logo and basic turtle geometry commands or simple shapes; and gave the Grade 3 and 6/7 teacher an opportunity to teach modular programming (Figures 11.44, 11.45, and 11.46). The Grade 6/7 teacher also used the same challenge to teach students how to plan the layout of a design by plotting it on graph paper, and by thinking through the problem and procedures before working at the computer. (This was primarily motivated by the need to make best use of the limited computer-time that each student had.) Most students started their early attempts in the Direct Draw mode. The younger students explored only at this level, some of the older students were also satisfied to explore at that level; however, other students became increasingly sophisticated in their attempts to meet the challenge. Some Grade 8 students challenged themselves further by creating colour effects and finer details, and by combining houses into villages.

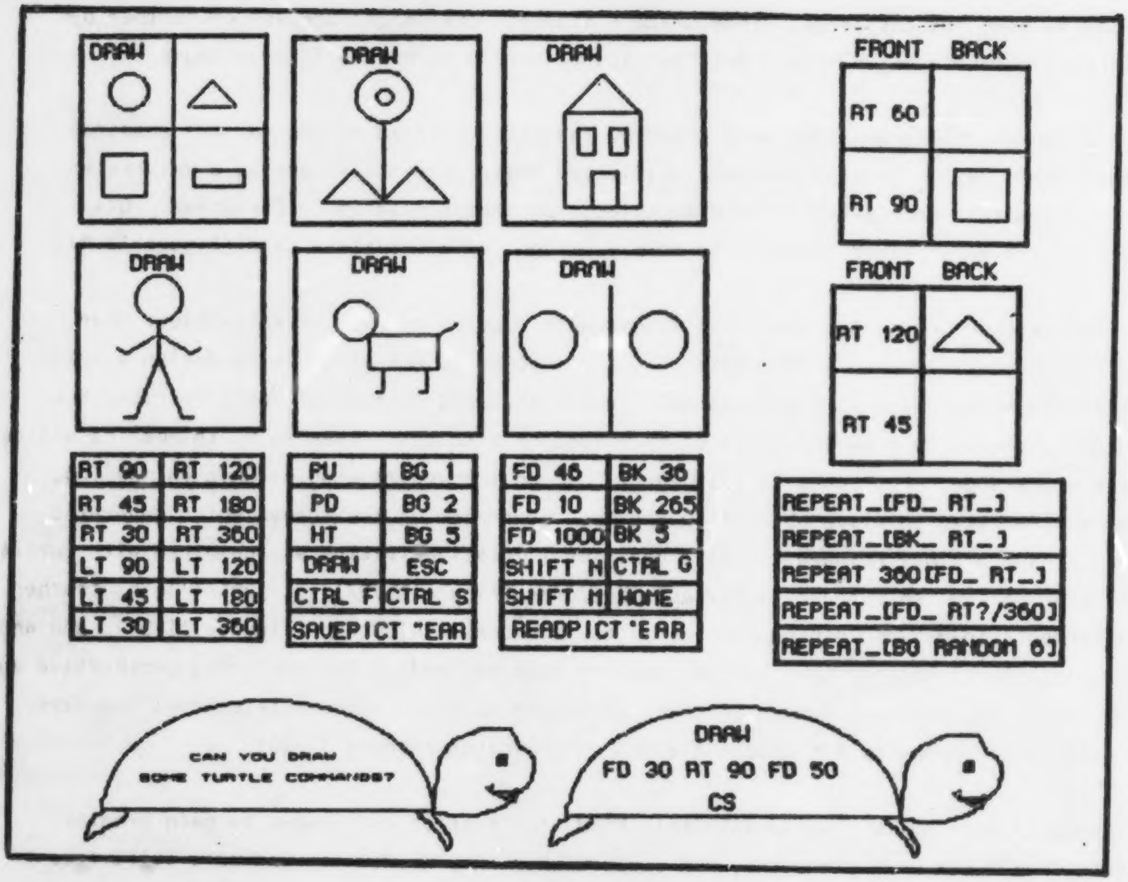
Additional challenges that were given by teachers, related to the various seasonal events. For example, several teachers challenged their students to create a Hallowe'en picture, to make a snowflake, or to draw objects or themes related to Christmas. One junior-level teacher asked students to make a design for a Christmas card (Figure 11.47).

Some teachers connected their challenges with regular curricular activities. For example, a Grade 3 teacher used a science unit on space to get students to design a space scene and to write a story (Figure 11.48). While studying animals of North America, she asked her students to draw a picture of an animal or bird that lives in North America and to write a story about it (Figure 11.49). During an environmental studies unit on mapping, students were asked to place objects in the four quadrants on the screen which generated several "road" designs (Figure 11.50). Additional creative writing was combined with turtle graphics at Hallowe'en (Figure 11.51) and Christmas (Figure 11.52). A junior-level teacher asked students to draw something that reflected a recent field trip (Figures 11.53); and an intermediate-level teacher used turtle geometry as a new medium for exploring perspective and string art during his art classes (Figures 11.54 and 11.55). Intermediate-level teachers also used turtle geometry for teaching about co-ordinates (Figure 11.56).

Students were quite pleased with this kind of direction and seemed to gain greater pleasure from their work since they had support when they needed it, yet were still free to exercise their imagination and to develop some independence.

Figure 11.23

Examples of Instruction Cards Used by Grade 1 Students


DRAW
DRAW
DRAW
FRONT BACK
RT 60
RT 90
DRAW
DRAW
DRAW
FRONT BACK
RT 120
RT 45
CAN YOU DRAW
SOME TURTLE COMMANDS?
DRAW
FD 30 RT 90 FD 50
CS

RT 90	RT 120
RT 45	RT 180
RT 30	RT 360
LT 90	LT 120
LT 45	LT 180
LT 30	LT 360

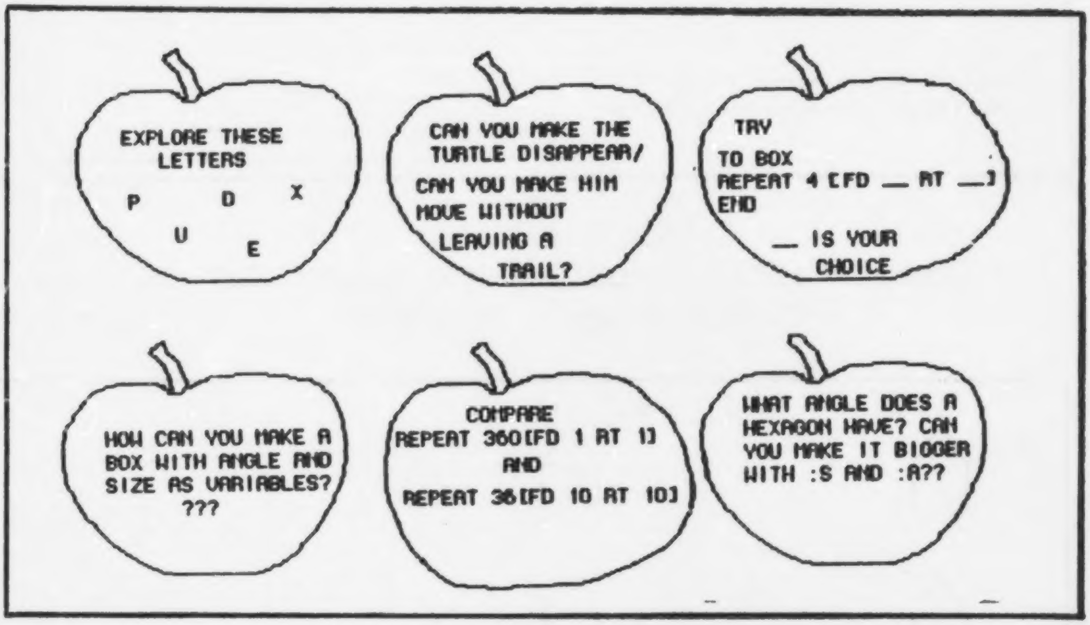
PU	BG 1
PD	BG 2
HT	BG 5
DRAW	ESC
CTRL F	CTRL S
SAVEPICT "EAR	

FD 46	BK 36
FD 10	BK 265
FD 1000	BK 5
SHIFT N	CTRL G
SHIFT M	HOME
READPICT 'EAR	

REPEAT_[FD_ RT_]
REPEAT_[BK_ RT_]
REPEAT 360[FD_ RT_]
REPEAT_[FD_ RT?/360]
REPEAT_[BG RANDOM 6]

Figure 11.24

Examples of 'Apple Challenges' Used by Grade 6/7 Students



EXPLORE THESE LETTERS

P D X

U E

CAN YOU MAKE THE TURTLE DISAPPEAR/

CAN YOU MAKE HIM MOVE WITHOUT LEAVING A TRAIL?

TRY

```
TO BOX
REPEAT 4 [FD __ RT __]
END
```

__ IS YOUR CHOICE

HOW CAN YOU MAKE A BOX WITH ANGLE AND SIZE AS VARIABLES? ???

COMPARE

```
REPEAT 360[FD 1 RT 1]
```

AND

```
REPEAT 36[FD 10 RT 10]
```

WHAT ANGLE DOES A HEXAGON HAVE? CAN YOU MAKE IT BIGGER WITH :S AND :A??

Figure 11.25

Examples of Pictures and Directions Given to Grade 1 Students

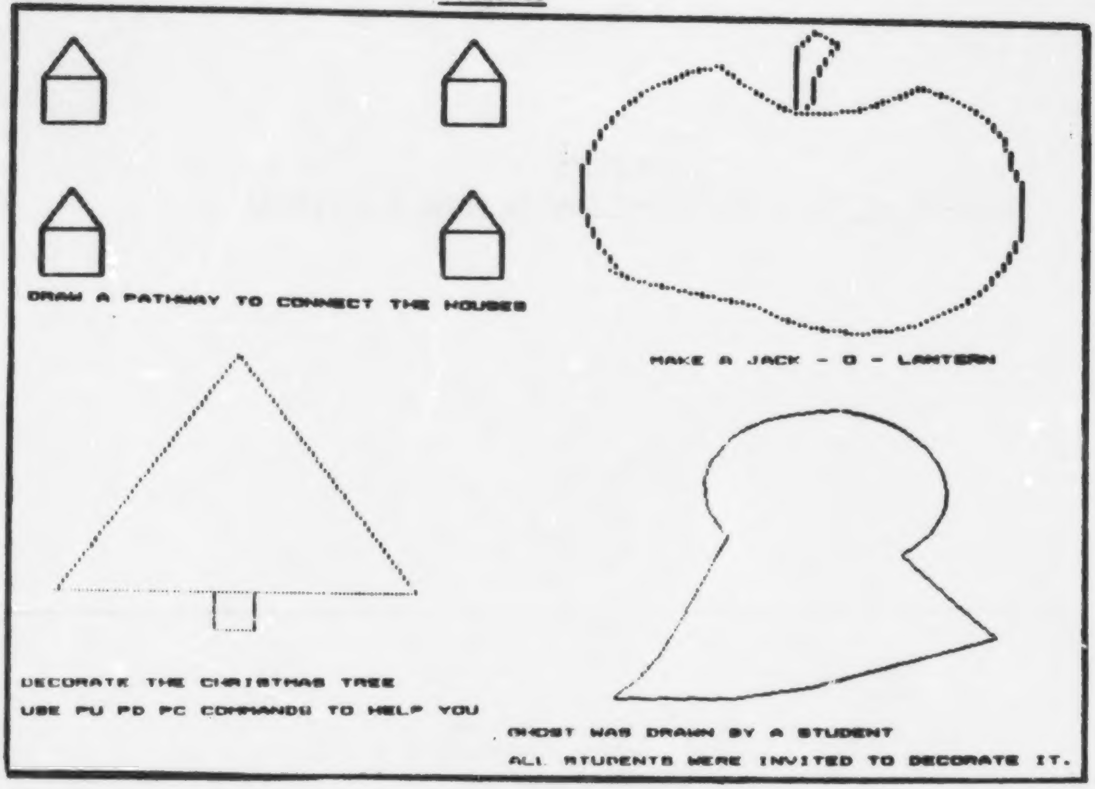

DRAW A PATHWAY TO CONNECT THE HOUSES
MAKE A JACK - O - LANTERN
DECORATE THE CHRISTMAS TREE
USE PU PD PC COMMANDS TO HELP YOU
GHOST WAS DRAWN BY A STUDENT
ALL STUDENTS WERE INVITED TO DECORATE IT.

Figure 11.26

Examples of Attempts by Grade 1 Students to Connect Four Houses Predesigned by the Teacher

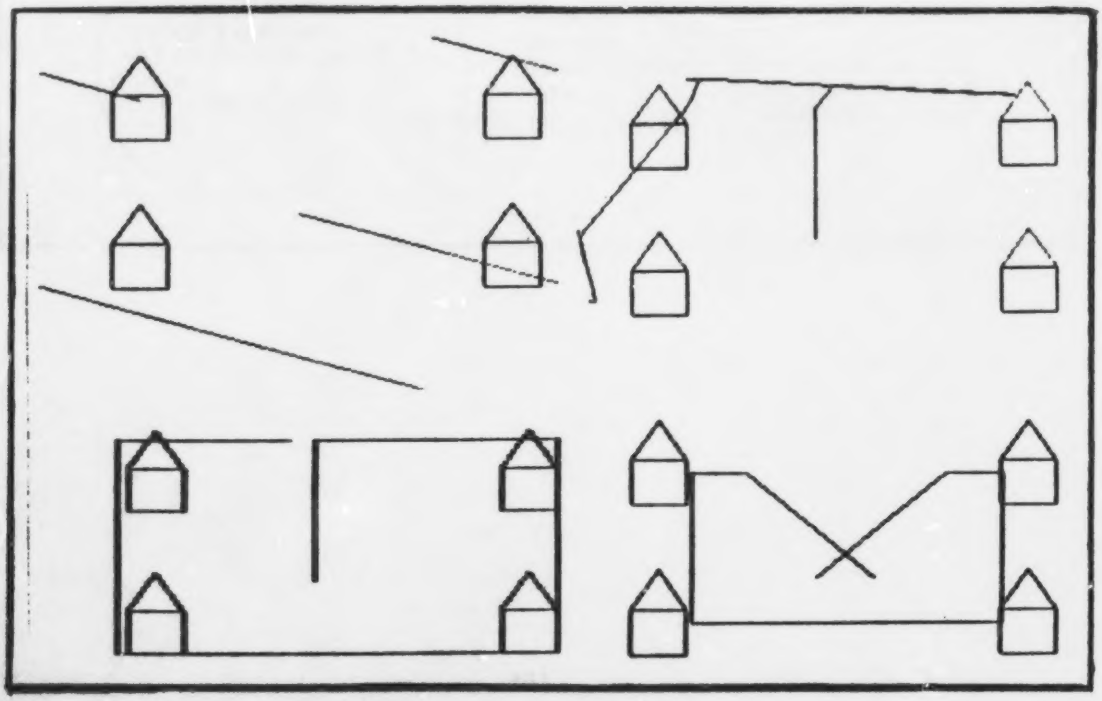


Figure 11.27

Examples of Placing Details on Predefined Shapes by Grade 1 Students

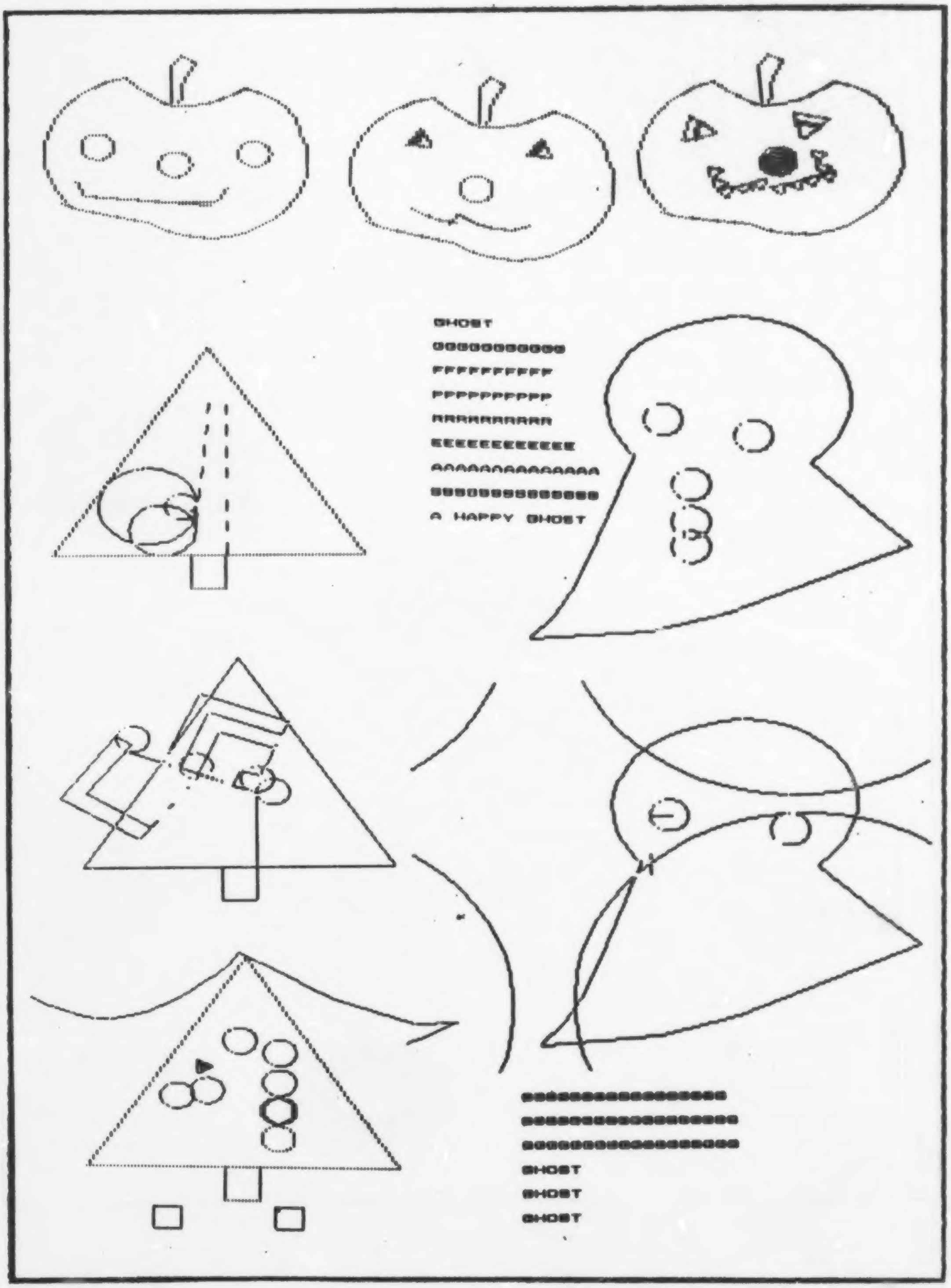

GHOST
GGGGGGGGGGG
FFFFFFFFFFF
PPPPPPPPPPP
RRRRRRRRRRR
EEEEEEEEEEEE
AAAAAAAAAAAAAA
SSSSSSSSSSSSSS
A HAPPY GHOST
GHOST
GHOST
GHOST

Figure 11.28

Examples of Drawings by Grade 1 Students Using Different Simple Shapes or Formulae Presented by the Teacher

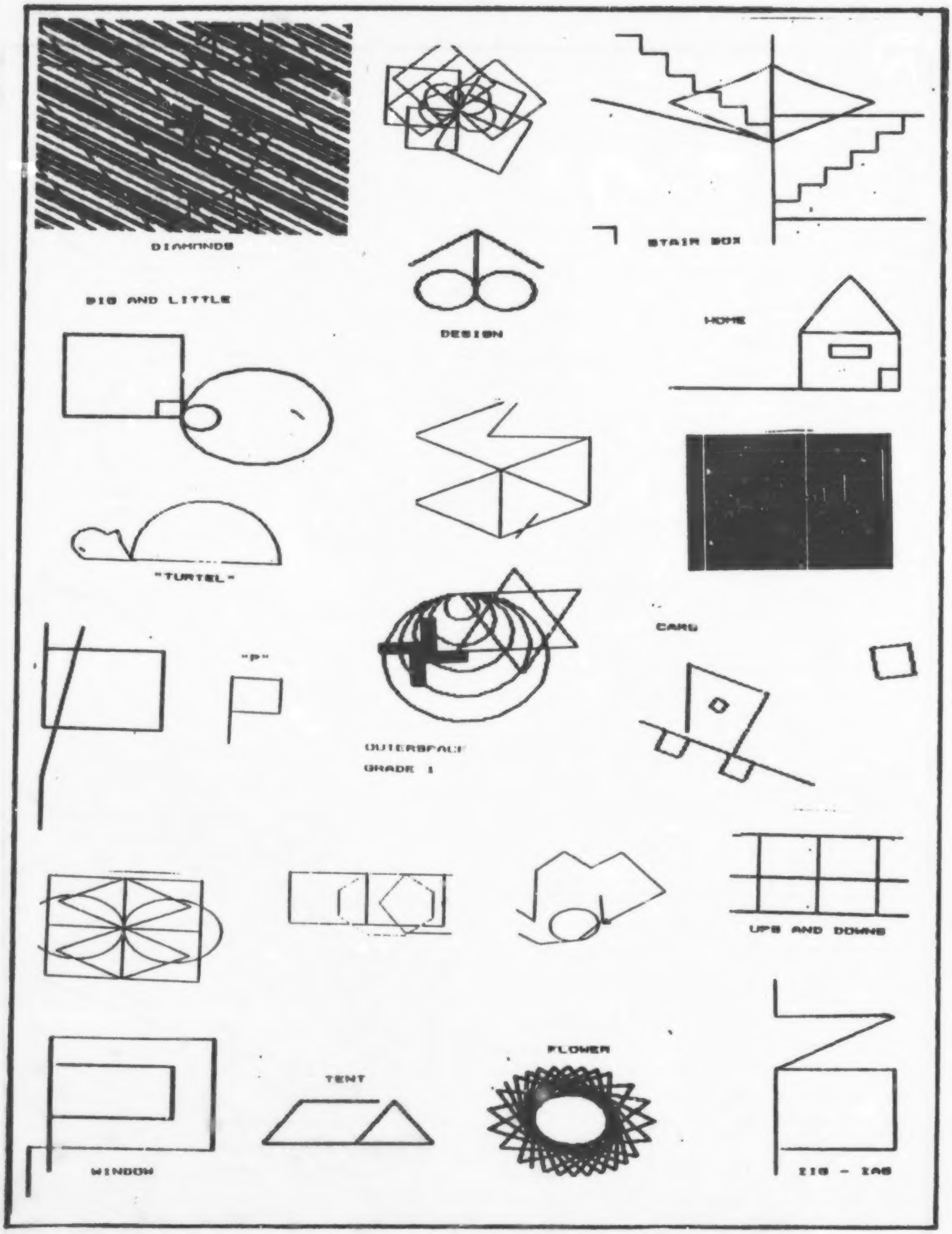
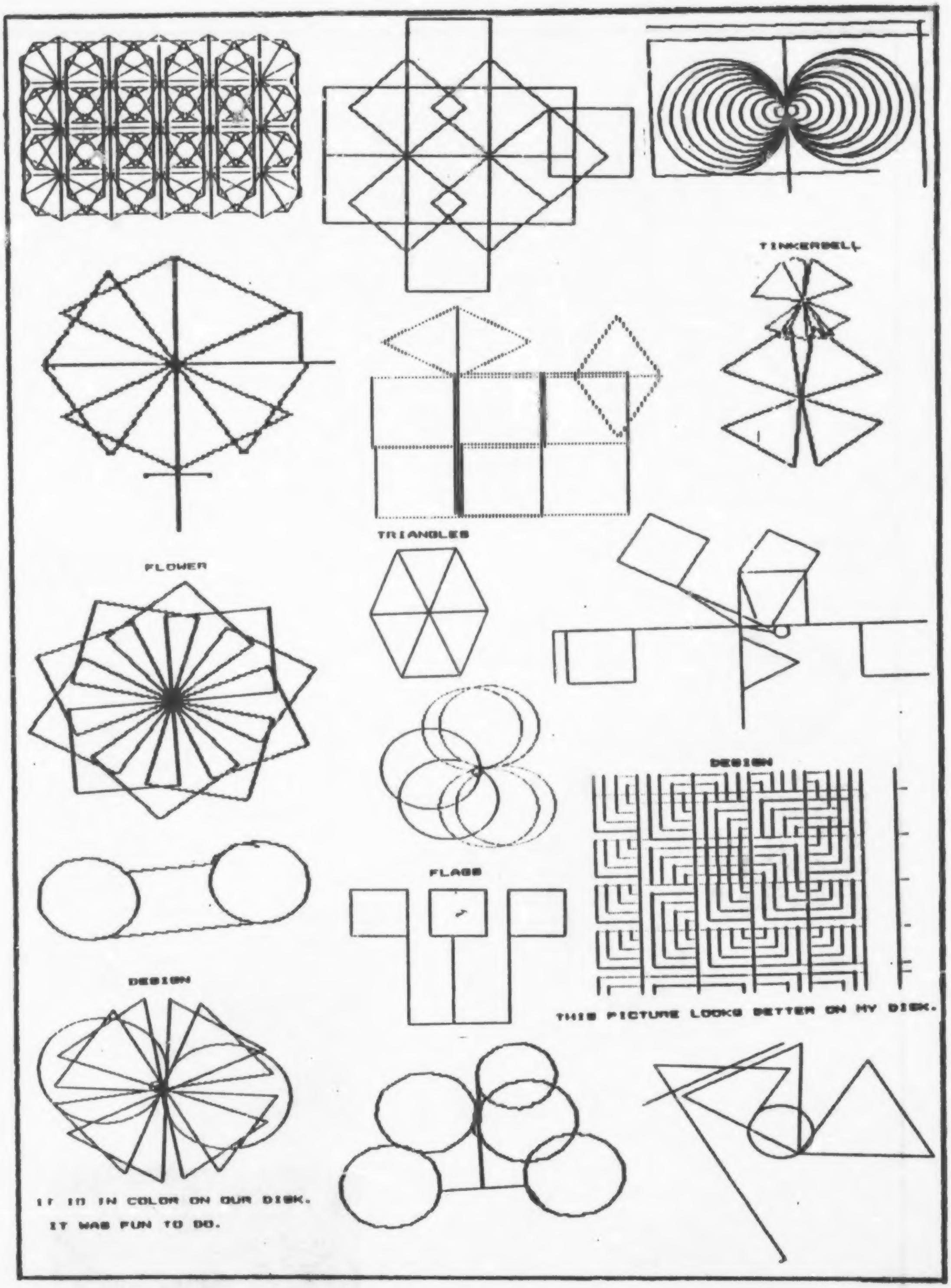

DIAMONDS
STAIR BOX
BIG AND LITTLE
DESIGN
HOME
"TURTEL"
"P"
OUTERSPACE
GRADE 1
CARS
UPS AND DOWNS
FLOWER
TENT
WINDOW
ZIG - ZAG

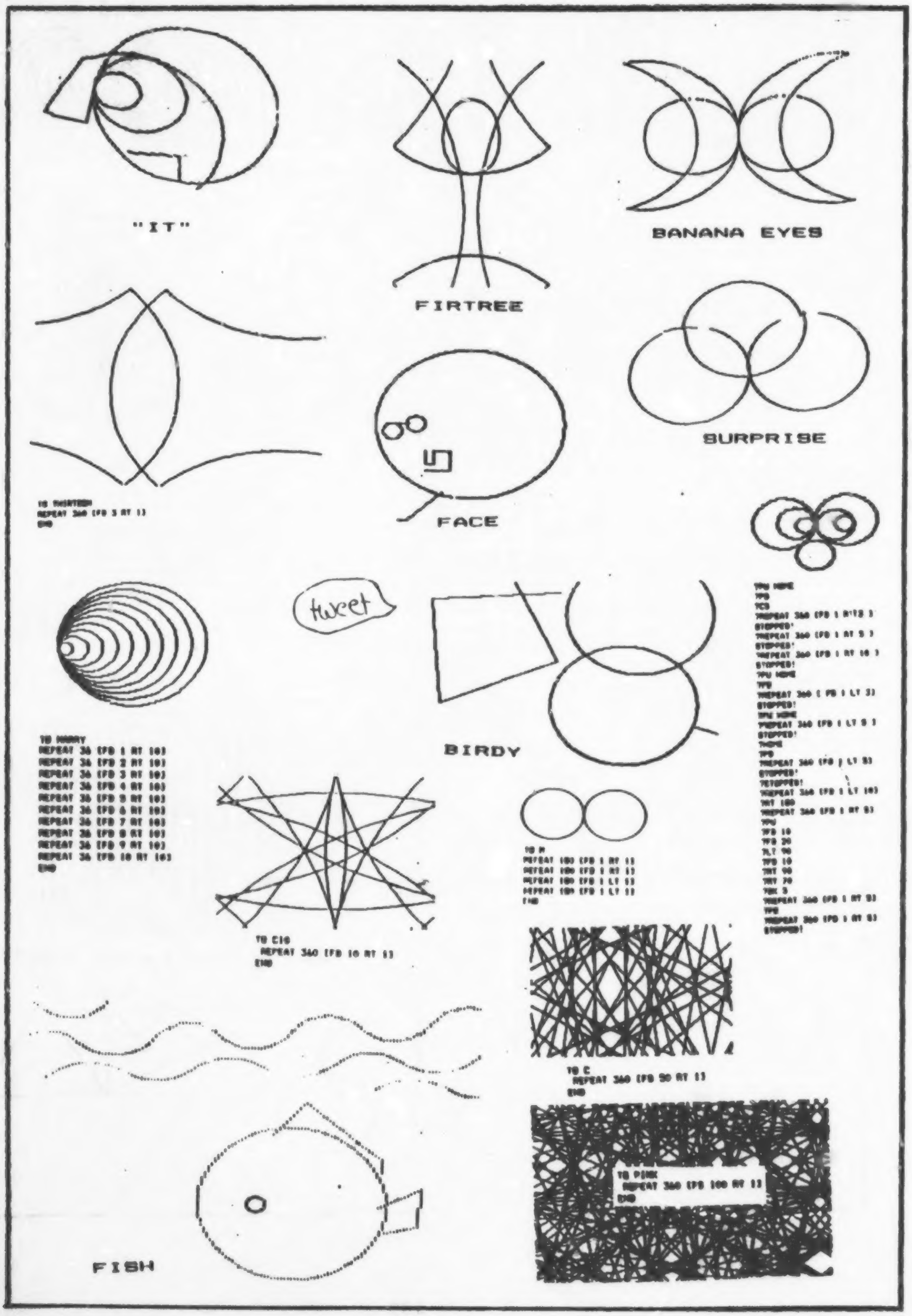
Figure 11.29

Examples of Drawings by Grade 3 Students in Response to the Challenge: "Make a Design Using Triangles, Circles and Squares" Following a Lesson on Shapes


TINKERBELL
TRIANGLES
FLOWER
DESIGN
FLAGS
THIS PICTURE LOOKS BETTER ON MY DISK.
DESIGN
IT IS IN COLOR ON OUR DISK.
IT WAS FUN TO DO.

<u>Figure 11.30</u>

<u>Examples of Drawings by Grade 5 Students in Response to the Challenge "Explore with Circles" following a Lesson on Making Circles</u>



```
TO THIRTEEN
REPEAT 360 [FD 3 RT 1]
END
```

```
TO HARRY
REPEAT 36 [FD 1 RT 10]
REPEAT 36 [FD 2 RT 10]
REPEAT 36 [FD 3 RT 10]
REPEAT 36 [FD 4 RT 10]
REPEAT 36 [FD 5 RT 10]
REPEAT 36 [FD 6 RT 10]
REPEAT 36 [FD 7 RT 10]
REPEAT 36 [FD 8 RT 10]
REPEAT 36 [FD 9 RT 10]
REPEAT 36 [FD 10 RT 10]
END
```

```
?PU HOME
?PD
?CS
?REPEAT 360 [FD 1 RT 2 ]
STOPPED!
?REPEAT 360 [FD 1 RT 5 ]
STOPPED!
?REPEAT 360 [FD 1 RT 10 ]
STOPPED!
?PU HOME
?PD
?REPEAT 360 [ FD 1 LT 3]
STOPPED!
?PU HOME
?REPEAT 360 [FD 1 LT 5 ]
STOPPED!
?HOME
?PD
?REPEAT 360 [FD 1 LT 5]
STOPPED!
?STOPPED!
?REPEAT 360 [FD 1 LT 10]
?RT 180
?REPEAT 360 [FD 1 RT 5]
?PU
?FD 10
?FD 20
?LT 90
?FD 10
?RT 90
?RT 70
?BK 5
?REPEAT 360 [FD 1 RT 5]
?PD
?REPEAT 360 [FD 1 RT 5]
STOPPED!
```

```
TO M
REPEAT 180 [FD 1 RT 1]
REPEAT 180 [FD 1 RT 1]
REPEAT 180 [FD 1 LT 1]
REPEAT 180 [FD 1 LT 1]
END
```

```
TO C10
 REPEAT 360 [FD 10 RT 1]
END
```

```
TO C
 REPEAT 360 [FD 50 RT 1]
END
```

```
TO PINK
 REPEAT 360 [FD 100 RT 1]
END
```

Figure 11.31

Examples of Drawings by Grade 3 Students in Response to the Challenge "Draw an Animal or Creature Using Simple Shapes"

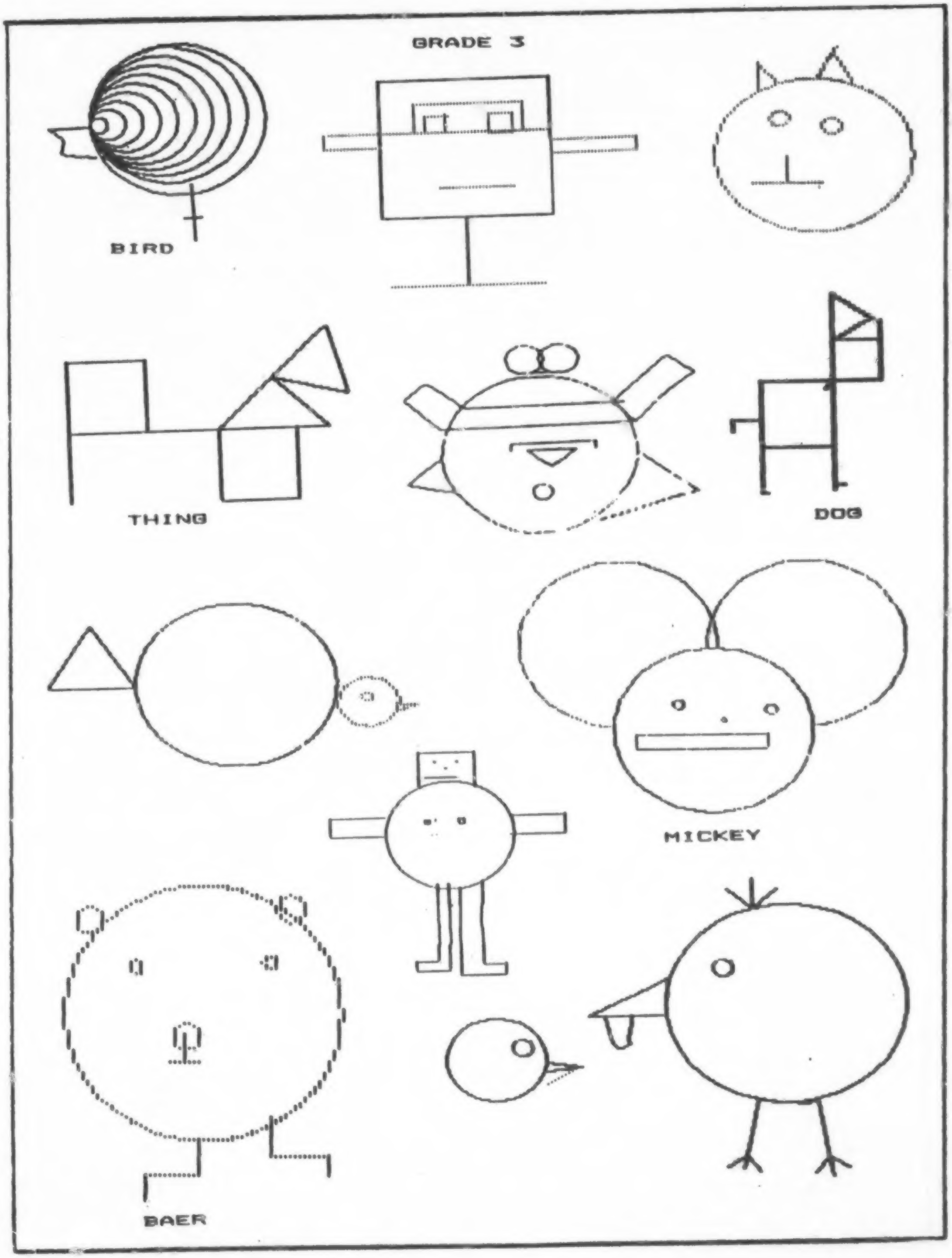

GRADE 3
BIRD
THING
DOG
MICKEY
BAER

Figure 11.32

Examples of Drawings made by Grade 5 Students in Response to the Challenge "Create Animals, Using Different Shapes"

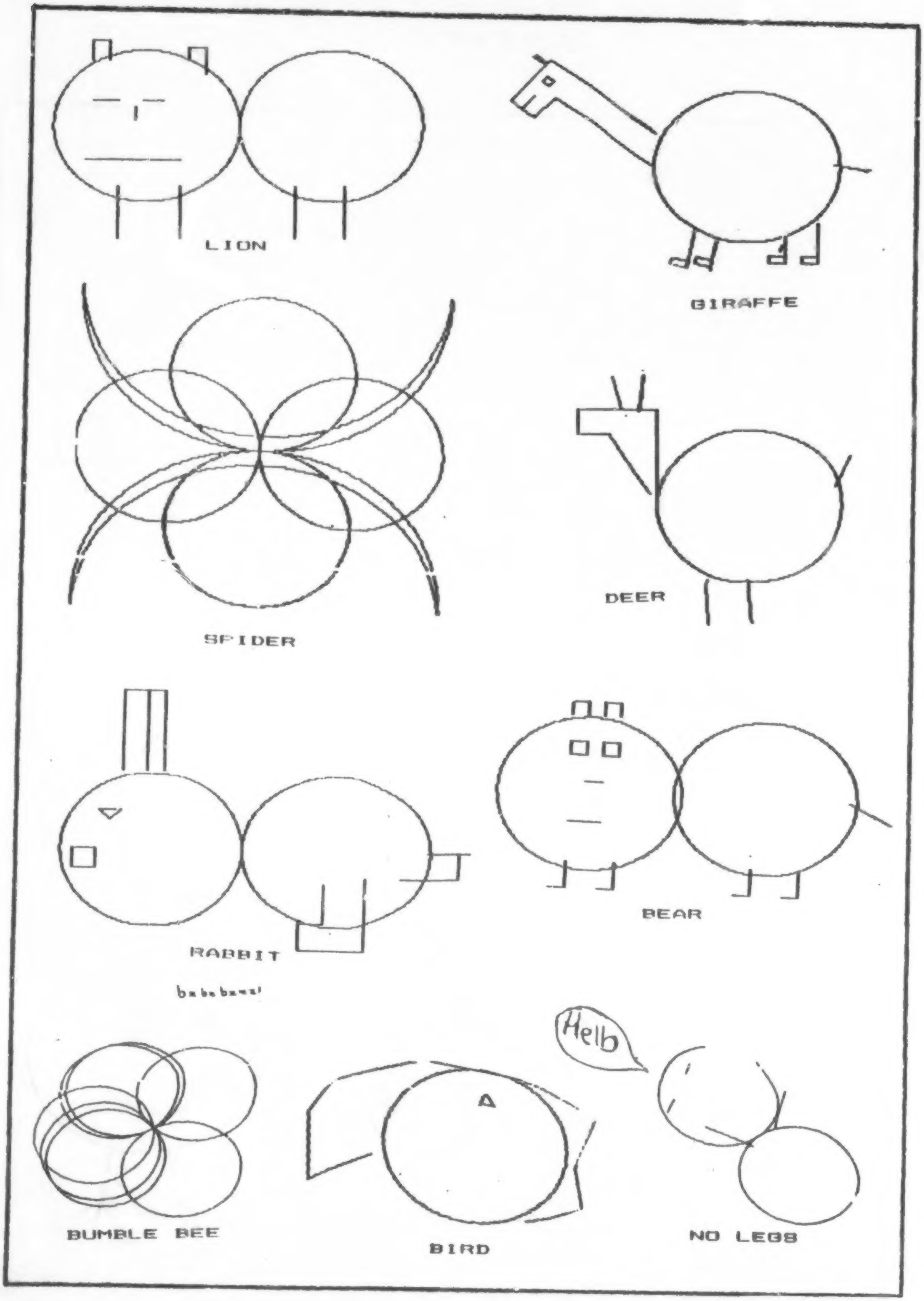
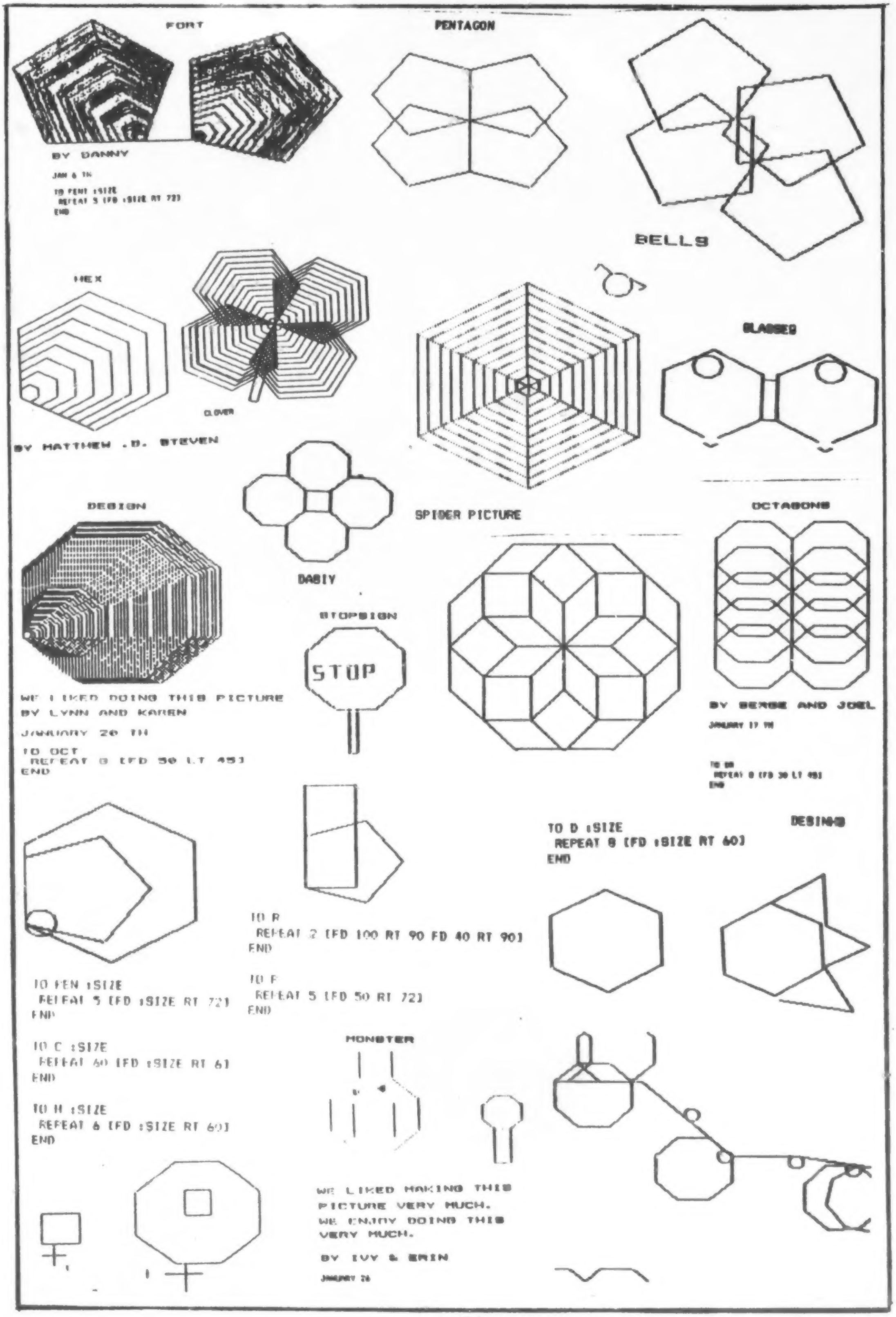

LION
GIRAFFE
SPIDER
DEER
RABBIT
BEAR
bzbzbzzz!
Helb
BUMBLE BEE
BIRD
NO LEGS

Figure 11.33

Examples of Designs Produced by Grade 3 Students Following a Lesson on Polygons


FORT
PENTAGON
BY DANNY
JAN 6 TH
BELLS
HEX
CLOVER
BY MATTHEW .D. STEVEN
GLASSES
DESIGN
DAISY
SPIDER PICTURE
OCTAGONS
STOPSIGN
STOP
WE LIKED DOING THIS PICTURE
BY LYNN AND KAREN
JANUARY 26 TH
BY SERGE AND JOEL
JANUARY 17 TH
DESINGS
MONSTER
WE LIKED MAKING THIS
PICTURE VERY MUCH.
WE ENJOY DOING THIS
VERY MUCH.
BY IVY & ERIN
JANUARY 26

```
TO PENT :SIZE
 REPEAT 5 [FD :SIZE RT 72]
END
```

```
TO OCT
 REPEAT 8 [FD 50 LT 45]
END
```

```
TO OO
 REPEAT 8 [FD 30 LT 45]
END
```

```
TO D :SIZE
 REPEAT 8 [FD :SIZE RT 60]
END
```

```
TO R
 REPEAT 2 [FD 100 RT 90 FD 40 RT 90]
END
```

```
TO F
 REPEAT 5 [FD 50 RT 72]
END
```

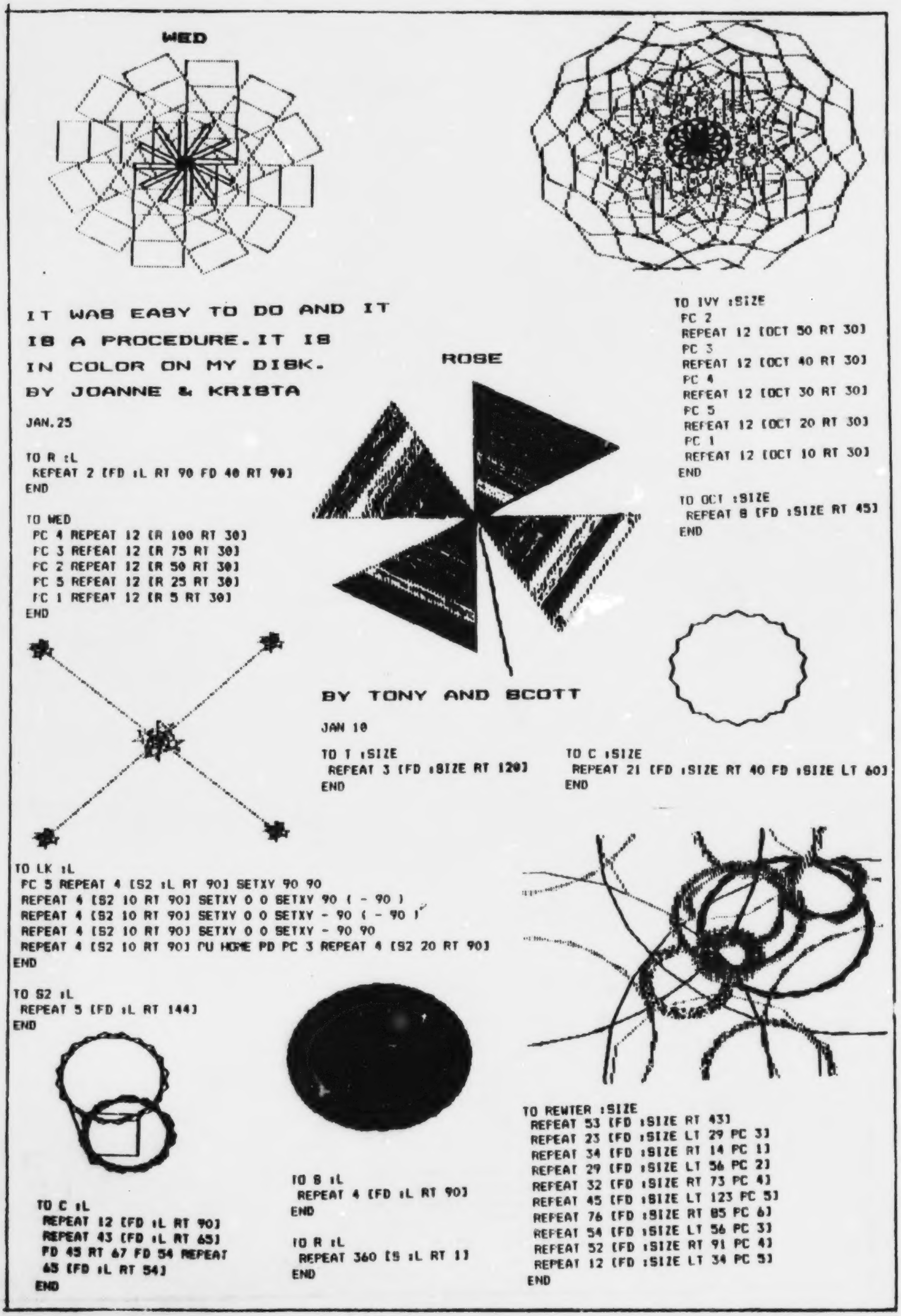
```
TO PEN :SIZE
 REPEAT 5 [FD :SIZE RT 72]
END
```

```
TO C :SIZE
 REPEAT 60 [FD :SIZE RT 6]
END
```

```
TO H :SIZE
 REPEAT 6 [FD :SIZE RT 60]
END
```

Figure 11.34

Examples of Designs Produced by Grade 3 Students Following a Lesson on Variables



IT WAS EASY TO DO AND IT
IS A PROCEDURE. IT IS
IN COLOR ON MY DISK.
BY JOANNE & KRISTA

JAN. 25

```
TO R :L
 REPEAT 2 [FD :L RT 90 FD 40 RT 90]
END

TO WED
 PC 4 REPEAT 12 [R 100 RT 30]
 PC 3 REPEAT 12 [R 75 RT 30]
 PC 2 REPEAT 12 [R 50 RT 30]
 PC 5 REPEAT 12 [R 25 RT 30]
 PC 1 REPEAT 12 [R 5 RT 30]
END
```

```
TO IVY :SIZE
 PC 2
 REPEAT 12 [OCT 50 RT 30]
 PC 3
 REPEAT 12 [OCT 40 RT 30]
 PC 4
 REPEAT 12 [OCT 30 RT 30]
 PC 5
 REPEAT 12 [OCT 20 RT 30]
 PC 1
 REPEAT 12 [OCT 10 RT 30]
END

TO OCT :SIZE
 REPEAT 8 [FD :SIZE RT 45]
END
```

BY TONY AND SCOTT

JAN 10

```
TO T :SIZE
 REPEAT 3 [FD :SIZE RT 120]
END
```

```
TO C :SIZE
 REPEAT 21 [FD :SIZE RT 40 FD :SIZE LT 60]
END
```

```
TO LK :L
 PC 5 REPEAT 4 [S2 :L RT 90] SETXY 90 90
 REPEAT 4 [S2 10 RT 90] SETXY 0 0 SETXY 90 ( - 90 )
 REPEAT 4 [S2 10 RT 90] SETXY 0 0 SETXY - 90 ( - 90 )
 REPEAT 4 [S2 10 RT 90] SETXY 0 0 SETXY - 90 90
 REPEAT 4 [S2 10 RT 90] PU HOME PD PC 3 REPEAT 4 [S2 20 RT 90]
END

TO S2 :L
 REPEAT 5 [FD :L RT 144]
END
```

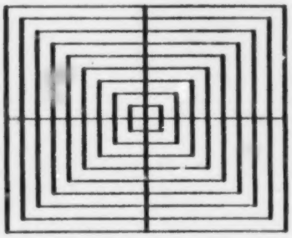
```
TO C :L
 REPEAT 12 [FD :L RT 90]
 REPEAT 43 [FD :L RT 65]
 FD 45 RT 67 FD 54 REPEAT
 65 [FD :L RT 54]
END
```

```
TO S :L
 REPEAT 4 [FD :L RT 90]
END

TO R :L
 REPEAT 360 [S :L RT 1]
END
```

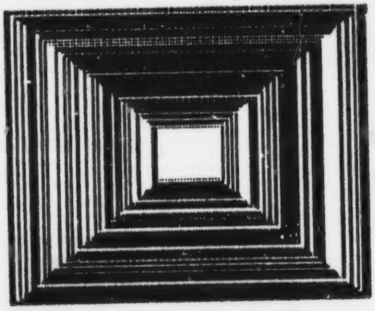
```
TO REWTER :SIZE
 REPEAT 53 [FD :SIZE RT 43]
 REPEAT 23 [FD :SIZE LT 29 PC 3]
 REPEAT 34 [FD :SIZE RT 14 PC 1]
 REPEAT 29 [FD :SIZE LT 56 PC 2]
 REPEAT 32 [FD :SIZE RT 73 PC 4]
 REPEAT 45 [FD :SIZE LT 123 PC 5]
 REPEAT 76 [FD :SIZE RT 85 PC 6]
 REPEAT 54 [FD :SIZE LT 56 PC 3]
 REPEAT 52 [FD :SIZE RT 91 PC 4]
 REPEAT 12 [FD :SIZE LT 34 PC 5]
END
```

Figure 11.35

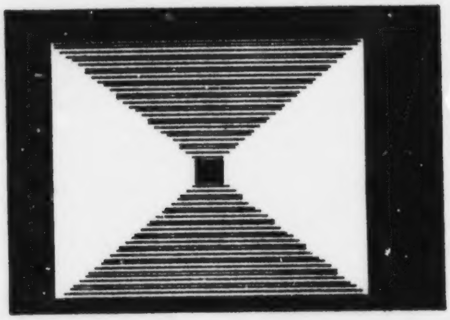
Examples of Responses Produced by Grade 6/7 Students to the Challenge "Centre a Group of Squares on the Screen"



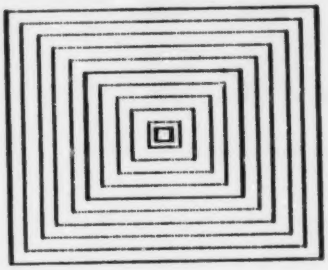
```
TO BURP1
BOX 10 BOX 20 BOX 30 BOX 50 BOX 40 BOX 60 BOX 70 BOX 80 BOX 90 LT 90
BOX 10 BOX 20 BOX 30 BOX 40 BOX 50 BOX 60 BOX 70 BOX 80 BOX 90 LT 90
BOX 10 BOX 20 BOX 30 BOX 40 BOX 50
BOX 60 BOX 70 BOX 80 BOX 90 LT 90
BOX 10 BOX 20 BOX 30 BOX 40 BOX 50 BOX 60 BOX 70 BOX 80 BOX 90 LT 90
END

TO BOX :S
REPEAT 4 [FD :S RT 90]
END
```



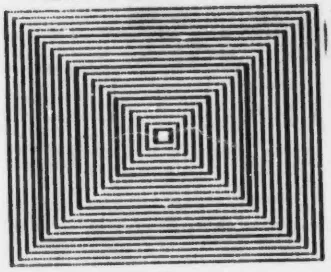
```
TO TOMMER :S
TOM :S
TOMMER :S + 1
END

TO TOM :B
PU BK :B LT 90 FD :B RT 90 PD
REPEAT 4 [SETPC RANDOM 5 FD :B * 2 RT 90]
PU SETPOS [0 0] PD
END

TO TOMMER1 :S
TOM :S
TOMMER :S + 1
END
```



```
TO SQ :S
REPEAT 4 [FD :S RT 90]
END

TO RET :S
IF :S > 200 [STOP]
HT SETBG 1 SETPC 0
SQ :S
FD :S RT 90
RET :S + 2
END
```



```
TO APE :A :B :C
PU BK :A LT 90 FD :B RT 90 PD
REPEAT 4 [FD :C RT 90]
PU HOME PD
END

TO APE1
SETPC 1 APE 5 5 10
SETPC 2 APE 10 10 20
SETPC 3 APE 20 20 40
SETPC 4 APE 30 30 60
SETPC 5 APE 40 40 80
SETPC 1 APE 50 50 100
SETPC 2 APE 60 60 120
SETPC 3 APE 70 70 140
SETPC 4 APE 80 80 160
SETPC 5 APE 90 90 180
SETPC 1 APE 100 100 200
END
```

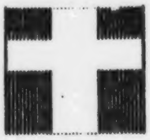


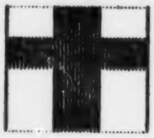
```
TO CERT1
CERT LT 90 CERT RT 180 CERT PU
HOME LT 180 PD CERT
END

TO BOX :S
PU FD :S PD RT 90 FD :S RT 90 FD :S
RT 90 PU FD :S RT 90
END
```

```
TO CERT
SETPC 1
BOX 5
SETPC 2
BOX 10
SETPC 3
BOX 15
SETPC 4
BOX 20
SETPC 5
BOX 25
SETPC 1
BOX 30
SETPC 2
BOX 35
SETPC 3
BOX 40
SETPC 4
BOX 45
SETPC 5
BOX 50
SETPC 1
BOX 55
SETPC 2
BOX 60
SETPC 3
BOX 65
SETPC 4
BOX 70
SETPC 5
BOX 75
SETPC 1
BOX 80
SETPC 2
BOX 85
SETPC 3
BOX 90
SETPC 4
BOX 95
SETPC 5
BOX 100
END
```

Figure 11.36

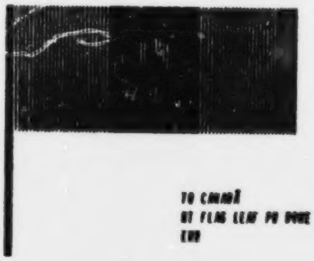
A Series of Flags Designed by Grade 6/7 Students As a Spin-off to the Challenge "Make a Bar Graph"



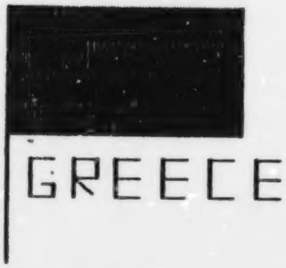


```
TO BB01
BB2 PU HOME PD BB3 PU HOME PD BB4 PU HOME PD
BB5 PU HOME PD BB
END

TO BB2
PD SETPC 2 REPEAT 25 [RT 90 FD 50 RT 90 FD 1 RT 90]
FD 50 RT 90
END

TO BB3
PD FD 25 SETPC 2 REPEAT 12 [RT 90 FD 50 LT 90 FD 1]
LT 90 FD 50 RT 90 FD 1
END

TO BB4
PD SETPC 2 FD 50 RT 90 FD 75 REPEAT 13 [RT 90 FD 25]
LT 90 FD 1 LT 90 FD 25 RT 90 FD 1
END

TO BB5
PD RT 180 FD 25 LT 90 FD 75 SETPC 2
REPEAT 13 [LT 90 FD 25 RT 90 FD 1]
RT 90 FD 25 LT 90 FD 1
END

TO BB
FD 50 LT 90 FD 25 RT 90 FD 25 RT 90 FD 25 LT 90
FD 25 RT 90 FD 25 RT 90 FD 25 LT 90 FD 25 RT 90
FD 75 RT 90 FD 25 LT 90 FD 50 RT 90 FD 50 RT 90
FD 100 RT 90 FD 75 RT 90 FD 100 RT 90 FD 25
END
```

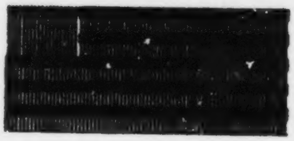
```
TO CR
CR1 PU HOME PD CR2 PU HOME PD
SW
END

TO CR2
PD RT 180 FD 25 LT 90 FD 50 SETPC 3 REPEAT 13 [LT 90 FD 75 RT 90 FD 1
RT 90 FD 75 LT 90 FD 1]
END

TO CR1
PD SETPC 3 REPEAT 13 [RT 90 FD 100 LT 90 FD 1 LT 90 FD 100 RT 90 FD 1]
END

TO BBLAST
BB01 PU HOME PD CR
END
```



```
TO [illegible]
HT FLAG [illegible] PU HOME PD POLE [illegible]
END
```

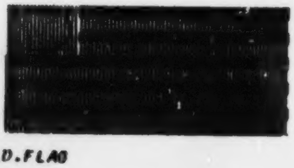


```
TO THE.GREEK.FLAG.FIN
RECYCLE CS
FULLSCREEN
FLAG
GREECE2
CLEARTEXT
WAIT 1000
SPLITSCREEN
PR [DESIGNED BY MARIA
```



```
TO FLAG,USTATES
HT
PU LT 90 FD 50 RT 90 PD
REPEAT 2 [FD 100 RT 90 FD 150 RT 90]
FD 60 RT 90 FD 40 LT 90 FD 40
PU HOME
STARS STRIPES STAR3
END
```

```
TO REC
RT 90 PU BK 50 PD FD 150 LT 90 FD 100 LT 90 FD 150 LT 90 FD 100
END

TO COLOUR :FC :RE :B
SETPC :PC REPEAT :RE [FD :B RT 90 FD 1 RT 90 FD :B LT 90 FD 1 LT 90]
END

TO FLAG
REC
BK 50 LT 90 FD 50 LT 90 FD 50 LT 90 FD 35 RT 90 BK 15 RT 90 BK 15
RT 90 FD 35 LT 90 FD 15 LT 90 FD 15 LT 90 FD 15
PU BK 50 PD FD 15 LT 90 FD 15 PU BK 50 PD FD 15 LT 90 FD 15
RT 90 BK 15 LT 90
COLOUR 5 7 100
COLOUR 1 7 100
COLOUR 5 7 100
COLOUR 1 5 100
LT 90 FD 2 RT 90 BK 50
COLOUR 5 7 150
COLOUR 1 7 150
COLOUR 5 7 150
COLOUR 1 5 150
LT 90 BK 100 FD 200 FD 1 RT 90
COLOUR 5 7 15
PU FD 35 LT 90 FD 15 RT 90 FD
COLOUR 5 8 13
FD 15 LT 90 SETPC 1 FD 15 BK 35 RT 90 BK 15
COLOUR 5 7 15
SETPC 1 FD 15 LT 90 FD 15 BK 15 RT 90 BK 50 LT 90 FD 15 RT 90
COLOUR 5 8 15
LT 90 FD 1 RT 90 SETPC 1 FD 15 BK 15 LT 90 FD 50 RT 90 FD 15
COLOUR 1 9 18
BK 15 LT 90 FD 2 RT 90
COLOUR 1 10 50
PU FD 15 PD
COLOUR 1 7 18
END
```

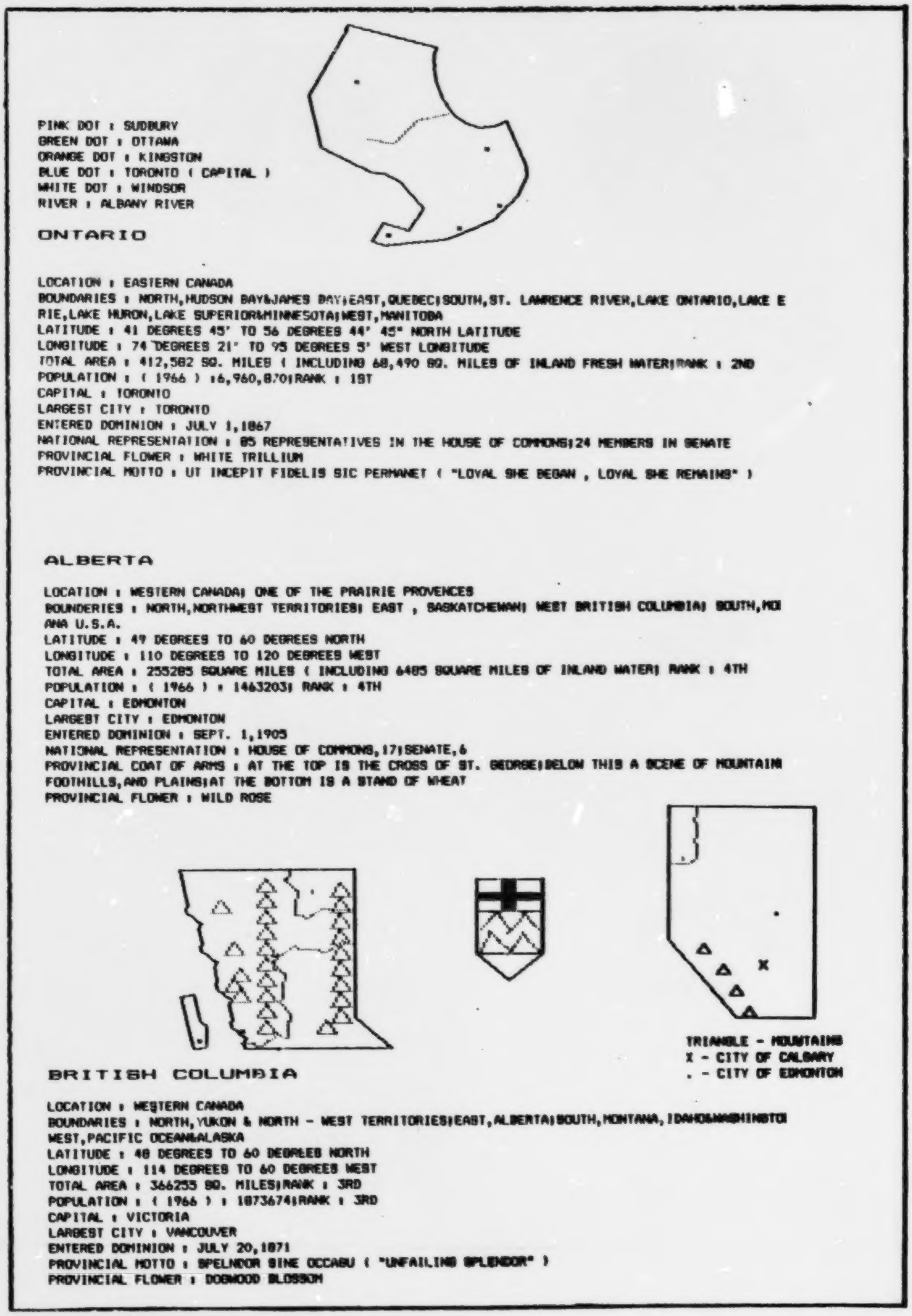


```
TO OLD.FLAG
HT
PU LT 90 FD 50 RT 90 PD
REPEAT 2 [FD 100 RT 90 FD 150 RT 90]
FD 60 RT 90 FD 40 LT 90 FD 40
PU HOME
STARS STRIPES STAR2
END
```

```
TO GREECE2
PU LT 90 BK 100 PD G 30 PU BK 20 RT 90 BK 10 PD R 30 LT 45 PU
FD 15 LT 90 BK 3 PD E 30 PU FD 15 LT 90 PD E 30 PU FD 15
LT 90 PD C 30 PU FD 15 LT 90 PD E 30
END
```

Figure 11.37

Drawings of Three Provinces of Canada Together with Appropriate Statistics Produced by Two Grade 7 Students

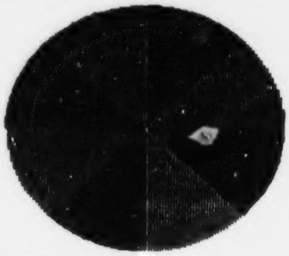


```
PINK DOT : SUDBURY
GREEN DOT : OTTAWA
ORANGE DOT : KINGSTON
BLUE DOT : TORONTO ( CAPITAL )
WHITE DOT : WINDSOR
RIVER : ALBANY RIVER

ONTARIO

LOCATION : EASTERN CANADA
BOUNDARIES : NORTH,HUDSON BAY&JAMES BAY;EAST,QUEBEC;SOUTH,ST. LAWRENCE RIVER,LAKE ONTARIO,LAKE E
RIE,LAKE HURON,LAKE SUPERIOR&MINNESOTA;WEST,MANITOBA
LATITUDE : 41 DEGREES 45' TO 56 DEGREES 44' 45" NORTH LATITUDE
LONGITUDE : 74 DEGREES 21' TO 95 DEGREES 5' WEST LONGITUDE
TOTAL AREA : 412,582 SQ. MILES ( INCLUDING 68,490 SQ. MILES OF INLAND FRESH WATER;RANK : 2ND
POPULATION : ( 1966 ) :6,960,870;RANK : 1ST
CAPITAL : TORONTO
LARGEST CITY : TORONTO
ENTERED DOMINION : JULY 1,1867
NATIONAL REPRESENTATION : 85 REPRESENTATIVES IN THE HOUSE OF COMMONS;24 MEMBERS IN SENATE
PROVINCIAL FLOWER : WHITE TRILLIUM
PROVINCIAL MOTTO : UT INCEPIT FIDELIS SIC PERMANET ( "LOYAL SHE BEGAN , LOYAL SHE REMAINS" )


ALBERTA

LOCATION : WESTERN CANADA; ONE OF THE PRAIRIE PROVENCES
BOUNDERIES : NORTH,NORTHWEST TERRITORIES; EAST , SASKATCHEWAN; WEST BRITISH COLUMBIA; SOUTH,MOI
ANA U.S.A.
LATITUDE : 49 DEGREES TO 60 DEGREES NORTH
LONGITUDE : 110 DEGREES TO 120 DEGREES WEST
TOTAL AREA : 255285 SQUARE MILES ( INCLUDING 6485 SQUARE MILES OF INLAND WATER; RANK : 4TH
POPULATION : ( 1966 ) : 1463203; RANK : 4TH
CAPITAL : EDMONTON
LARGEST CITY : EDMONTON
ENTERED DOMINION : SEPT. 1,1905
NATIONAL REPRESENTATION : HOUSE OF COMMONS,17;SENATE,6
PROVINCIAL COAT OF ARMS : AT THE TOP IS THE CROSS OF ST. GEORGE;BELOW THIS A SCENE OF MOUNTAINS
FOOTHILLS,AND PLAINS;AT THE BOTTOM IS A STAND OF WHEAT
PROVINCIAL FLOWER : WILD ROSE

TRIANGLE - MOUNTAINS
X - CITY OF CALGARY
. - CITY OF EDMONTON

BRITISH COLUMBIA

LOCATION : WESTERN CANADA
BOUNDARIES : NORTH,YUKON & NORTH - WEST TERRITORIES;EAST,ALBERTA;SOUTH,MONTANA,IDAHO&WASHINGTO
WEST,PACIFIC OCEAN&ALASKA
LATITUDE : 48 DEGREES TO 60 DEGREES NORTH
LONGITUDE : 114 DEGREES TO 60 DEGREES WEST
TOTAL AREA : 366255 SQ. MILES;RANK : 3RD
POPULATION : ( 1966 ) : 1873674;RANK : 3RD
CAPITAL : VICTORIA
LARGEST CITY : VANCOUVER
ENTERED DOMINION : JULY 20,1871
PROVINCIAL MOTTO : SPELNDOR SINE OCCASU ( "UNFAILING SPLENDOR" )
PROVINCIAL FLOWER : DOGWOOD BLOSSOM
```

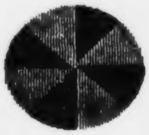
Figure 11.38

Examples of Responses by Grade 6/7 Students to the Challenge

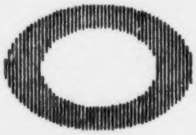
"Make a Pie Graph"



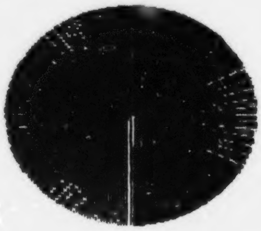
```
TO COLOUR44
 HT
 SETPC 1
 REPEAT 90 [RT 1/2 FD 100 BK 100]
 SETPC 2
 REPEAT 90 [RT 1/2 FD 100 BK 100]
 SETPC 1
 REPEAT 90 [RT 1/2 FD 100 BK 100]
 SETPC 3
 REPEAT 90 [RT 1/2 FD 100 BK 100]
 SETPC 1
 REPEAT 90 [RT 1/2 FD 100 BK 100]
 SETPC 4
 REPEAT 90 [RT 1/2 FD 100 BK 100]
 SETPC 1
 REPEAT 90 [RT 1/2 FD 100 BK 100]
 SETPC 2
 REPEAT 90 [RT 1/2 FD 100 BK 100]
END
```



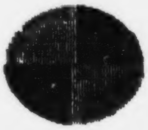
```
TO COLOUR :S
 HT
 REPEAT 45 [SETPC 4 FD :S RT 1 BK :S]
 REPEAT 45 [SETPC 3 FD :S RT 1 BK :S]
 REPEAT 45 [SETPC 2 FD :S RT 1 BK :S]
 REPEAT 45 [SETPC 5 FD :S RT 1 BK :S]
 REPEAT 45 [SETPC 1 FD :S RT 1 BK :S]
 REPEAT 45 [SETPC 4 FD :S RT 1 BK :S]
 REPEAT 45 [SETPC 3 FD :S RT 1 BK :S]
 REPEAT 45 [SETPC 5 FD :S RT 1 BK :S]
END
```



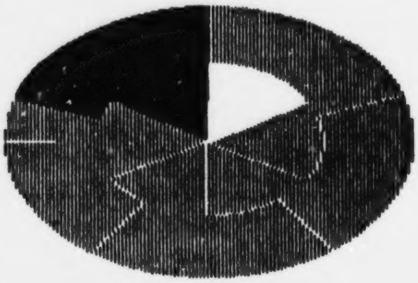
```
TO O2
O O1
END

TO O
SETPC 2
REPEAT 360 [FD 50 BK 50 RT 1]
END

TO O1
SETPC 0
REPEAT 360 [FD 30 BK 30 RT 1]
END
```



```
TO KNOT2
 REPEAT 60 [SETPC 1 RT 1 FD 90 BK 90]
 REPEAT 60 [SETPC 2 RT 1 FD 90 BK 90]
 REPEAT 60 [SETPC 1 RT 1 FD 90 BK 90]
 REPEAT 60 [SETPC 3 RT 1 FD 90 BK 90]
 REPEAT 60 [SETPC 1 RT 1 FD 90 BK 90]
 REPEAT 60 [SETPC 4 RT 1 FD 90 BK 90]
 PC 4 BK 90 PU FD 90 PD
END
```



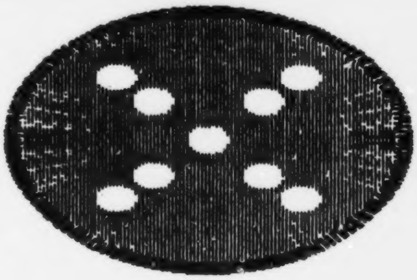
```
TO FILLING
 HT
 SETPC 5
 REPEAT 180 [FD 50 RT 180 FD 50 RT .5]
 SETPC 1
 REPEAT 180 [FD 50 RT 180 FD 50 RT .5]
 PU HOME PD
END
```



```
TO BO
BOB BOBBY
END

TO BOB
REPEAT 360 [SETPC 5 FD 110 BK 110 RT .2]
REPEAT 360 [SETPC 4 FD 110 BK 110 RT .2]
REPEAT 360 [SETPC 3 FD 110 BK 110 RT .2]
REPEAT 360 [SETPC 2 FD 110 BK 110 RT .2]
REPEAT 360 [SETPC 1 FD 110 BK 110 RT .2]
END

TO BOBBY
REPEAT 60 [SETPC 1 FD 60 BK 60 LT 1]
REPEAT 60 [SETPC 2 FD 60 BK 60 LT 1]
REPEAT 60 [SETPC 3 FD 60 BK 60 LT 1]
REPEAT 60 [SETPC 4 FD 60 BK 60 LT 1]
REPEAT 60 [SETPC 5 FD 60 BK 60 LT 1]
REPEAT 60 [SETPC 0 FD 60 BK 60 LT 1]
END
```

Figure 11.39

Two Programs for Making Pizzas Produced by Two Grade 6 and Two Grade 8 Students As a Spin-off From the "Pie Graph" Challenge



```
TO PIZZA
PR [TODAY WE ARE GOING TO MAKE A PIZZA]
WAIT 100
PR [FIRST WE START OUT WITH THE DOUGH]
WAIT 100
ST HT REPEAT 360 [FD 110 BK 110 RT 1]
PR [NEXT WE PUT ON THE TOMATO SAUCE]
WAIT 100
SETPC 4
REPEAT 360 [FD 100 BK 100 RT 1]
PR [NOW WE PUT ON THE PEPPERONIES]
WAIT 100
PEP
PR [SORRY THEY WERE A LITTLE BURNT]
PR [AND FINALLY WE PUT ON THE GREEN PEPPERS]
WAIT 100
PEPP
PR [THANK YOU FOR MAKING A PIZZA WITH US]
END
```

```
TO PEPP
SETPC 2
PU SETPOS [0 15] PD REPEAT 10 [FD 5 BK 5 RT 90 FD 1 LT 90]
PU SETPOS [0 -15] PD REPEAT 10 [FD 5 BK 5 RT 90 FD 1 LT 90]
PU SETPOS [50 25] PD REPEAT 10 [FD 5 BK 5 RT 90 FD 1 LT 90]
PU SETPOS [50 -25] PD REPEAT 10 [FD 5 BK 5 RT 90 FD 1 LT 90]
PU SETPOS [-50 -25] PD REPEAT 10 [FD 5 BK 5 RT 90 FD 1 LT 90]
PU SETPOS [-50 25] PD REPEAT 10 [FD 5 BK 5 RT 90 FD 1 LT 90]
END

TO PEP
SETPC 0 PU SETPOS [0 0] PD REPEAT 360 [FD 10 BK 10 RT 1]
PU SETPOS [30 -30] PD REPEAT 360 [FD 10 BK 10 RT 1]
PU SETPOS [30 30] PD REPEAT 360 [FD 10 BK 10 RT 1]
PU SETPOS [-30 -30] PD REPEAT 360 [FD 10 BK 10 RT 1]
PU SETPOS [-30 30] PD REPEAT 360 [FD 10 BK 10 RT 1]
PU SETPOS [50 50] PD REPEAT 360 [FD 10 BK 10 RT 1]
PU SETPOS [50 -50] PD REPEAT 360 [FD 10 BK 10 RT 1]
PU SETPOS [-50 -50] PD REPEAT 360 [FD 10 BK 10 RT 1]
PU SETPOS [-50 50] PD REPEAT 360 [FD 10 BK 10 RT 1]
END
```

```
TO PIZZA
 PC 4 REPEAT 180 [FD 100 BK 200 FD 100 RT 1] PU
 HOME PD PC 1
 REPEAT 180 [FD 80 BK 160 FD 80 RT 1] PU
 HOME
 FD 25
 PD PC 5
 REPEAT 180 [FD 10 BK 20 FD 10 RT 1] PU
 HOME
 BK 36 PC 5 PD REPEAT 180 [FD 10 BK 20 FD 10 RT 1]
 PU HOME RT 90 FD 68 PD
 REPEAT 180 [FD 10 BK 20 FD 10 RT 1]
 PU
 HOME LT 90 FD 35 PD
 REPEAT 180 [FD 10 BK 20 FD 10 RT 1]
 PU HOM
 E RT 36 FD 57 PD
 REPEAT 180 [FD 10 BK 20 FD 10 RT 1]
 PU HOME LT 35 FD 16 REPEAT 180 [FD 10 BK 20 FD 10 RT 1]
END
```

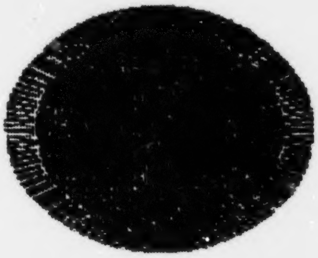
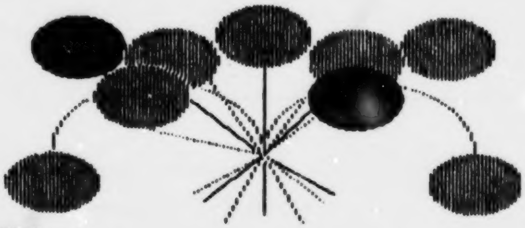
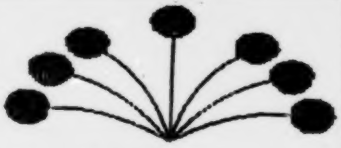


Figure 11.40

Examples of Balloons Created by Grade 6, 7 and 8 Students as a Spin-off From the "Pie Graph" Challenge



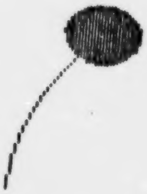
```
O BALLOONS
SETPC 5 HT
PU SETPOS [0 70] PD ENJOY 180 50 179 HOME RT 100 FD 50 HOME
SETPC 1
PU SETPOS [-100 60]
PD ENJOY 180 50 179 HOME RT 130 FD 50 HOME
SETPC 3
PU SETPOS [100 60] PD ENJOY 180 50 179 HOME LT 130 FD 50 PU HOME HT
SETPC 2
PU SETPOS [-50 50] PD ENJOY 180 50 179 HOME RT 160 FD 60 PU HOME
SETPC 4
PU
SETPOS [50 50] PD ENJOY 180 50 179 HOME
LT 160 PD FD 60 PU HOME PD
SETPC 5 ARCR ENJOY 180 50 179 PU HOME PD ARCL ENJOY 180 50 179
PU HOME PD
PU SETPOS [50 20] PD SETPC 1 ENJOY 180 50 179 HOME LT 140 FD 50
PU SETPOS [-50 65] PD SETPC 3 ENJOY 180 50 179 HOME RT 140 FD 50 PU HOME PD
WAIT 500
PR [THESE BALLOONS WERE MADE BY CHRISTINE!!!!!!!!!!!!!!]
END
```

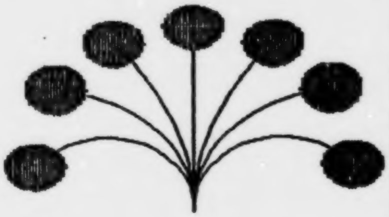


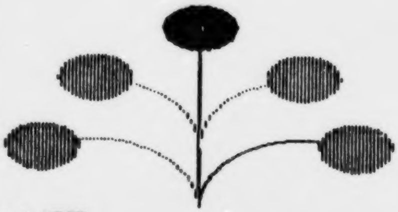
```
O BALLOONS1
PU BK 55 PD
REPEAT 15 [FD 10 RT 10]
PC 2 APPLE
POSE
REPEAT 15 [FD 10 LT 10]
PC 3 APPLE
POSE
REPEAT 15 [FD 10 RT 6]
PC 4 APPLE
POSE
REPEAT 15 [FD 10 LT 6]
PC 5 APPLE
POSE
REPEAT 15 [FD 10 RT 3]
PC 2 APPLE
POSE
REPEAT 15 [FD 10 LT 3]
PC 3 APPLE
POSE
FD 150
PC 2 APPLE
ND
```

```
O ENJOY :F :U :H
REPEAT :F [FD :U LT :H]
END
```

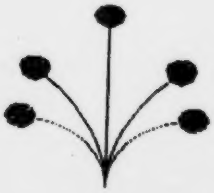
```
TO BALLOON
HT PU BK 80 PD
REPEAT 40 [FD 3 RT 1] PC 2
REPEAT 90 [FD 50 RT 1 BK 50 RT 1]
END
```







```
TO WEED
HT
BK 50 PD 150
PC 1 B
HOME BK 50
REPEAT 120 [FD 1 RT 1]
FC 4 B
PU
HOME PD
REPEAT 90 [FD 1 RT 1]
PC 2 B
PU
HOME
FD
REPEAT 90 [FD 1 LT 1]
PC 3 B
PU
HOME
BK 50 PD
REPEAT 120 [FD 1 LT 1]
PC 5 B
END
TO B
 REPEAT 90 [FD 20 BK 40
 FD 20 RT 2]
 END
```

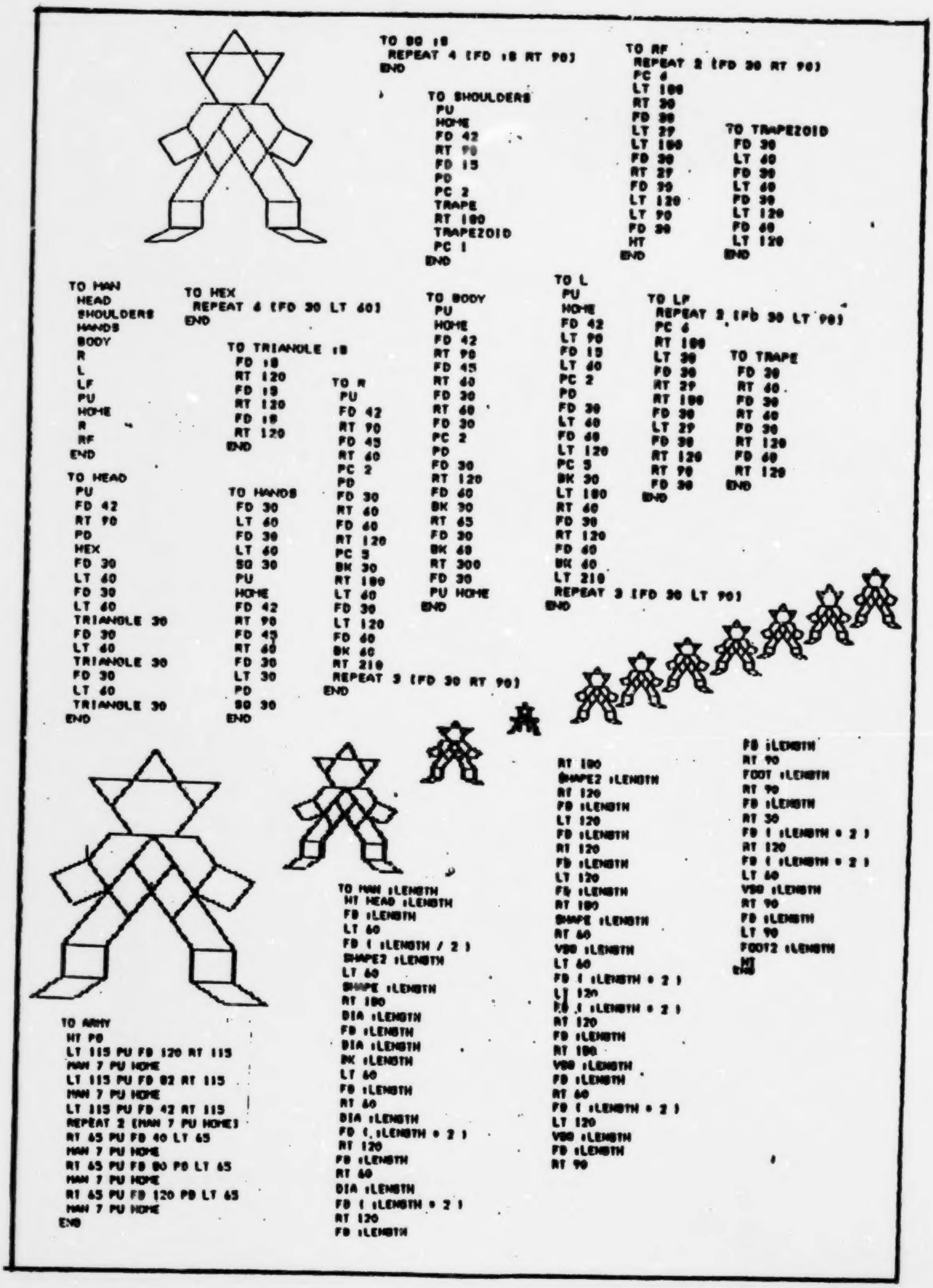


```
TO BALLOONS
 HT
 FD 50 BK 100 FD 100
 PC 4
 REPEAT 90 [BK 10 FD 20 BK 10 RT 2]
 PC 1 PU HOME PD
 BK 90 REPEAT 90 [FD 1 LT 1]
 PC 3
 REPEAT 90 [BK 10 FD 20 BK 10 RT 2]
 PU PC 1
 HOME BK 90 PD REPEAT 90 [FD 1 RT 1]
 PC 2 REPEAT 90 [BK 10 FD 20 BK 10 RT 2]
 PC 1 PU HOME BK 90 PD
 REPEAT 55 [FD 2 RT 1]
 REPEAT 90 [BK 10 FD 20 BK 10 RT 2]
 PU HOME BK 90 PD
 REPEAT 55 [FD 2 LT 1]
 PC 5 REPEAT 90 [BK 10 FD 20 BK 10 RT 2]
 PC 1
END
```

```
TO BALLS
 HT
 PU BK 25 RT 10 PD
 REPEAT 30 [FD 1 RT 1 FD 1]
 PU HOME BK 25 RT 30 PD
 REPEAT 50 [FD 1 RT 1 FD 1]
 PU HOME BK 25 RT 50 PD
 REPEAT 50 [FD 1 RT 1 FD 1]
 PU HOME BK 25 LT 10 PD
 REPEAT 50 [FD 1 LT 1 FD 1]
 PU HOME BK 25 LT 30 PD
 REPEAT 50 [FD 1 LT 1 FD 1]
 PU HOME BK 25 LT 50 PD
 REPEAT 50 [FD 1 LT 1 FD 1]
 REPEAT 180 [FD 14 BK 28 FD 14 RT 1]
 PC 5 PU HOME BK 25 LT 30
 REPEAT 50 [FD 1 LT 1 FD 1]
 PD PC 4
 REPEAT 180 [FD 14 BK 28 FD 14 RT 1]
 PU HOME BK 25 LT 10
 REPEAT 50 [FD 1 LT 1 FD 1]
 PD PC 3 BALLOONS PU
 HOME BK 25 RT 10
 REPEAT 30 [FD 1 RT 1 FD 1]
 PD PC 3 BALLOONS PU HOME
 BK 25 RT 30
 REPEAT 50 [FD 1 RT 1 FD 1]
 PD PC 4 BALLOONS PU HOME
 BK 25 RT 50
 REPEAT 50 [FD 1 RT 1 FD 1]
 PD PC 5 BALLOONS PU HOME BK 25
 PD FD 100 PC 2 BALLOONS
END
```

Figure 11.41

Examples of Two Common Strategies Used by Grade 8 Students in Response to the Challenge "Draw The 'Tesselated' Man Depicted in The Picture"

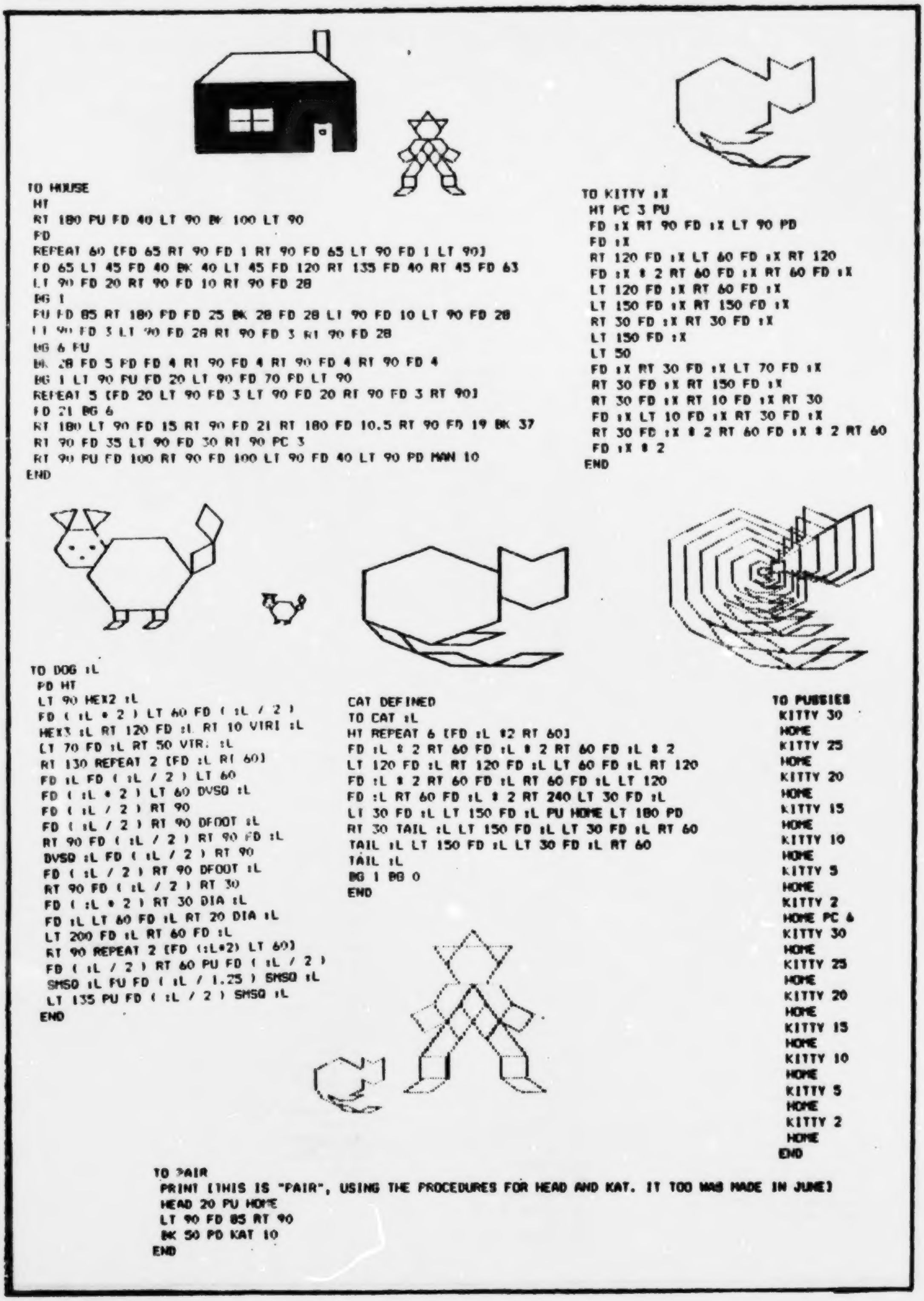


```
TO SQ :S
 REPEAT 4 [FD :S RT 90]
END

TO SHOULDERS
 PU
 HOME
 FD 42
 RT 90
 FD 15
 PD
 PC 2
 TRAPE
 RT 180
 TRAPEZOID
 PC 1
END

TO RF
 REPEAT 2 [FD 30 RT 90]
 PC 6
 LT 180
 RT 30
 FD 30
 LT 29
 LT 180
 FD 30
 RT 29
 FD 30
 LT 120
 LT 90
 FD 30
 HT
END

TO TRAPEZOID
 FD 30
 LT 60
 FD 30
 LT 60
 FD 30
 LT 120
 FD 60
 LT 120
END

TO MAN
 HEAD
 SHOULDERS
 HANDS
 BODY
 R
 L
 LF
 PU
 HOME
 R
 RF
END

TO HEX
 REPEAT 6 [FD 30 LT 60]
END

TO TRIANGLE :S
 FD :S
 RT 120
 FD :S
 RT 120
 FD :S
 RT 120
END

TO R
 PU
 FD 42
 RT 90
 FD 45
 RT 60
 PC 2
 PD
 FD 30
 RT 60
 FD 60
 RT 120
 PC 5
 BK 30
 RT 180
 LT 60
 FD 30
 LT 120
 FD 60
 BK 60
 RT 210
 REPEAT 3 [FD 30 RT 90]
END

TO BODY
 PU
 HOME
 FD 42
 RT 90
 FD 45
 RT 60
 FD 30
 RT 60
 FD 30
 PC 2
 PD
 FD 30
 RT 120
 FD 60
 BK 30
 RT 65
 FD 30
 BK 60
 RT 300
 FD 30
 PU HOME
END

TO L
 PU
 HOME
 FD 42
 LT 90
 FD 15
 LT 60
 PC 2
 PD
 FD 30
 LT 60
 FD 60
 LT 120
 PC 5
 BK 30
 LT 180
 RT 60
 FD 30
 RT 120
 FD 60
 BK 60
 LT 210
 REPEAT 3 [FD 30 LT 90]
END

TO LF
 REPEAT 2 [Fb 30 LT 90]
 PC 6
 RT 180
 LT 30
 FD 30
 RT 29
 RT 180
 FD 30
 LT 29
 FD 30
 RT 120
 RT 90
 FD 30
END

TO TRAPE
 FD 30
 RT 60
 FD 30
 RT 60
 FD 30
 RT 120
 FD 60
 RT 120
END

TO HEAD
 PU
 FD 42
 RT 90
 PD
 HEX
 FD 30
 LT 60
 FD 30
 LT 60
 TRIANGLE 30
 FD 30
 LT 60
 TRIANGLE 30
 FD 30
 LT 60
 TRIANGLE 30
END

TO HANDS
 FD 30
 LT 60
 FD 30
 LT 60
 SQ 30
 PU
 HOME
 FD 42
 RT 90
 FD 45
 RT 60
 FD 30
 LT 30
 PD
 SQ 30
END
```

```
TO ARMY
 HT PD
 LT 115 PU FD 120 RT 115
 MAN 7 PU HOME
 LT 115 PU FD 82 RT 115
 MAN 7 PU HOME
 LT 115 PU FD 42 RT 115
 REPEAT 2 [MAN 7 PU HOME]
 RT 65 PU FD 40 LT 65
 MAN 7 PU HOME
 RT 65 PU FD 80 PD LT 65
 MAN 7 PU HOME
 RT 65 PU FD 120 PD LT 65
 MAN 7 PU HOME
END

TO MAN :LENGTH
 HT HEAD :LENGTH
 FD :LENGTH
 LT 60
 FD ( :LENGTH / 2 )
 SHAPE2 :LENGTH
 LT 60
 SHAPE :LENGTH
 RT 180
 DIA :LENGTH
 FD :LENGTH
 DIA :LENGTH
 BK :LENGTH
 LT 60
 FD :LENGTH
 RT 60
 DIA :LENGTH
 FD ( :LENGTH * 2 )
 RT 120
 FD :LENGTH
 RT 60
 DIA :LENGTH
 FD ( :LENGTH * 2 )
 RT 120
 FD :LENGTH
 RT 180
 SHAPE2 :LENGTH
 RT 120
 FD :LENGTH
 LT 120
 FD :LENGTH
 RT 120
 FD :LENGTH
 LT 120
 FD :LENGTH
 RT 180
 SHAPE :LENGTH
 RT 60
 VSQ :LENGTH
 LT 60
 FD ( :LENGTH * 2 )
 LT 120
 FD ( :LENGTH * 2 )
 RT 120
 FD :LENGTH
 RT 180
 VSQ :LENGTH
 FD :LENGTH
 RT 60
 FD ( :LENGTH * 2 )
 LT 120
 VSQ :LENGTH
 FD :LENGTH
 RT 90
 FD :LENGTH
 RT 90
 FOOT :LENGTH
 RT 90
 FD :LENGTH
 RT 30
 FD ( :LENGTH * 2 )
 RT 120
 FD ( :LENGTH * 2 )
 LT 60
 VSQ :LENGTH
 RT 90
 FD :LENGTH
 LT 90
 FOOT2 :LENGTH
 HT
END
```

Figure 11.42

Examples of Responses by Grade 8 Students to the Challenge "Draw a Cat as Outlined in This Picture"



```
TO HOUSE
 HT
 RT 180 PU FD 40 LT 90 BK 100 LT 90
 FD
 REPEAT 60 [FD 65 RT 90 FD 1 RT 90 FD 65 LT 90 FD 1 LT 90]
 FD 65 LT 45 FD 40 BK 40 LT 45 FD 120 RT 135 FD 40 RT 45 FD 63
 LT 90 FD 20 RT 90 FD 10 RT 90 FD 28
 BG 1
 PU FD 85 RT 180 PD FD 25 BK 28 FD 28 LT 90 FD 10 LT 90 FD 28
 LT 90 FD 3 LT 90 FD 28 RT 90 FD 3 RT 90 FD 28
 BG 6 PU
 BK 28 FD 5 PD FD 4 RT 90 FD 4 RT 90 FD 4 RT 90 FD 4
 BG 1 LT 90 PU FD 20 LT 90 FD 70 PD LT 90
 REPEAT 5 [FD 20 LT 90 FD 3 LT 90 FD 20 RT 90 FD 3 RT 90]
 FD 21 BG 6
 RT 180 LT 90 FD 15 RT 90 FD 21 RT 180 FD 10.5 RT 90 FD 19 BK 37
 RT 90 FD 35 LT 90 FD 30 RT 90 PC 3
 RT 90 PU FD 100 RT 90 FD 100 LT 90 FD 40 LT 90 PD MAN 10
END
```

```
TO KITTY :X
 HT PC 3 PU
 FD :X RT 90 FD :X LT 90 PD
 FD :X
 RT 120 FD :X LT 60 FD :X RT 120
 FD :X * 2 RT 60 FD :X RT 60 FD :X
 LT 120 FD :X RT 60 FD :X
 LT 150 FD :X RT 150 FD :X
 RT 30 FD :X RT 30 FD :X
 LT 150 FD :X
 LT 50
 FD :X RT 30 FD :X LT 70 FD :X
 RT 30 FD :X RT 150 FD :X
 RT 30 FD :X RT 10 FD :X RT 30
 FD :X LT 10 FD :X RT 30 FD :X
 RT 30 FD :X * 2 RT 60 FD :X * 2 RT 60
 FD :X * 2
END
```

```
TO DOG :L
 PD HT
 LT 90 HEX2 :L
 FD ( :L * 2 ) LT 60 FD ( :L / 2 )
 HEX3 :L RT 120 FD :L RT 10 VIRI :L
 LT 70 FD :L RT 50 VIR: :L
 RT 130 REPEAT 2 [FD :L RT 60]
 FD :L FD ( :L / 2 ) LT 60
 FD ( :L * 2 ) LT 60 DVSQ :L
 FD ( :L / 2 ) RT 90
 FD ( :L / 2 ) RT 90 DFOOT :L
 RT 90 FD ( :L / 2 ) RT 90 FD :L
 DVSQ :L FD ( :L / 2 ) RT 90
 FD ( :L / 2 ) RT 90 DFOOT :L
 RT 90 FD ( :L / 2 ) RT 30
 FD ( :L * 2 ) RT 30 DIA :L
 FD :L LT 60 FD :L RT 20 DIA :L
 LT 200 FD :L RT 60 FD :L
 RT 90 REPEAT 2 [FD (:L*2) LT 60]
 FD ( :L / 2 ) RT 60 PU FD ( :L / 2 )
 SMSQ :L PU FD ( :L / 1.25 ) SMSQ :L
 LT 135 PU FD ( :L / 2 ) SMSQ :L
 END
```

```
CAT DEFINED
TO CAT :L
HT REPEAT 6 [FD :L *2 RT 60]
FD :L * 2 RT 60 FD :L * 2 RT 60 FD :L * 2
LT 120 FD :L RT 120 FD :L LT 60 FD :L RT 120
FD :L * 2 RT 60 FD :L RT 60 FD :L LT 120
FD :L RT 60 FD :L * 2 RT 240 LT 30 FD :L
LT 30 FD :L LT 150 FD :L PU HOME LT 180 PD
RT 30 TAIL :L LT 150 FD :L LT 30 FD :L RT 60
TAIL :L LT 150 FD :L LT 30 FD :L RT 60
TAIL :L
BG 1 BG 0
END
```

```
TO PUSSIES
 KITTY 30
 HOME
 KITTY 25
 HOME
 KITTY 20
 HOME
 KITTY 15
 HOME
 KITTY 10
 HOME
 KITTY 5
 HOME
 KITTY 2
 HOME PC 6
 KITTY 30
 HOME
 KITTY 25
 HOME
 KITTY 20
 HOME
 KITTY 15
 HOME
 KITTY 10
 HOME
 KITTY 5
 HOME
 KITTY 2
 HOME
END
```

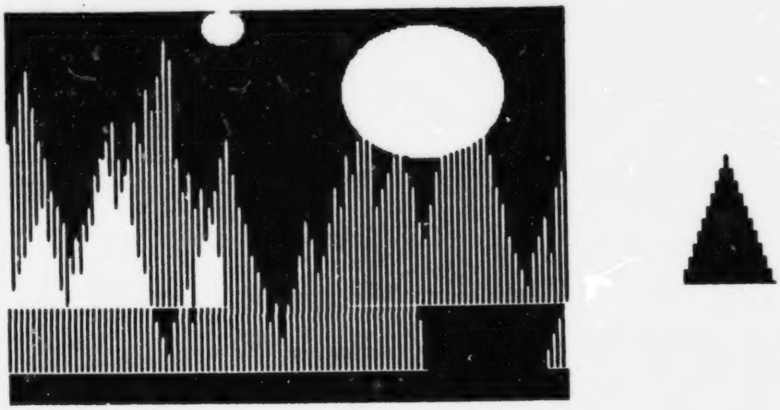
```
TO PAIR
 PRINT [THIS IS "PAIR", USING THE PROCEDURES FOR HEAD AND KAT. IT TOO WAS MADE IN JUNE]
 HEAD 20 PU HOME
 LT 90 FD 85 RT 90
 BK 50 PD KAT 10
END
```

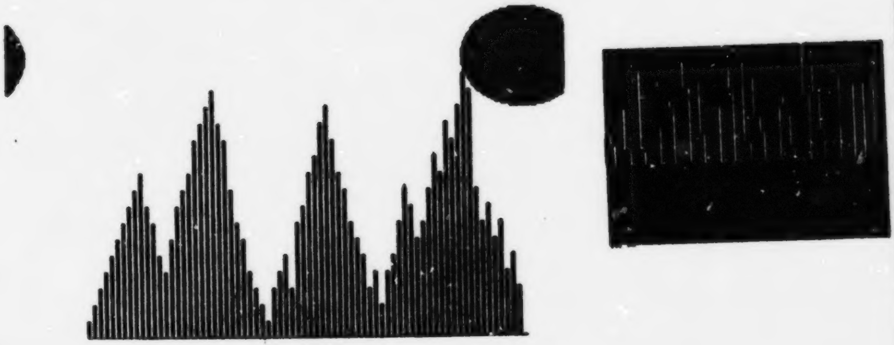
Figure 11.43

Examples of 'Landscape' Pictures Created by Grade 5 Students Following a Lesson on Variables and in Response to the Challenge "Design A Landscape"

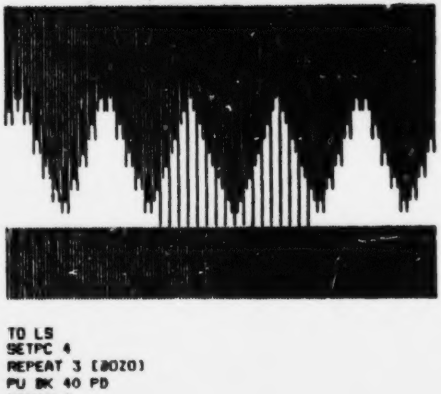
```
TO LANDSCAPE :SIZE
HT
PU
BK 100
LT 90
FD 100
RT 90
PD
MOUNT 10
MOUNT 20
MOUNT 30
MOUNT 40
MOUNT 50
MOUNT 60
MOUNT 70
MOUNT 80
MOUNT 90
MOUNT 100
MOUNT 80
MOUNT 70
MOUNT 50
MOUNT 40
MOUNT 60
MOUNT 80
MOUNT 90
MOUNT 100
MOUNT 120
MOUNT 130
MOUNT 140
MOUNT 150
MOUNT 130
MOUNT 120
MOUNT 90
MOUNT 70
MOUNT 60
MOUNT 40
MOUNT 30
MOUNT 20
MOUNT 10
MOUNT 30
MOUNT 40
MOUNT 50
MOUNT 30
MOUNT 70
MOUNT 80
MOUNT 100
MOUNT 110
MOUNT 130
MOUNT 140
MOUNT 120
MOUNT 100
MOUNT 90
MOUNT 70
MOUNT 60
MOUNT 50
MOUNT 30
MOUNT 40
MOUNT 20
MOUNT 40
MOUNT 50
MOUNT 70
MOUNT 90
```

```
TO FANTASYCITY
LANDSCAPE 40
PU HOME BK 200
LT 90 FD 100 RT 90 PD LANDSCAPE 10
SETBG 1
END
```





```
TO MOUNT :SIZE
FD :SIZE
BK :SIZE
RT 90
FD 3
LT 90
END
```



```
TO LS
SETPC 4
REPEAT 3 [BOZO]
PU BK 40 PD
SETPC 2
REPEAT 3 [BOZO]
PU BK 20 PD
SETPC 3
REPEAT 8 [BOZO]
SETBG 5
END
```

```
TO BOZO
HT
MOUNT 10
MOUNT 20
MOUNT 30
MOUNT 40
MOUNT 50
MOUNT 60
MOUNT 70
MOUNT 80
MOUNT 90
MOUNT 100
MOUNT 90
MOUNT 80
MOUNT 70
MOUNT 60
MOUNT 50
MOUNT 40
MOUNT 30
MOUNT 20
MOUNT 10
END
```

Figure 11.43

Examples of Houses Drawn by Kindergarten and Grade 1 Students Using Instant Logo or the Direct Draw Mode

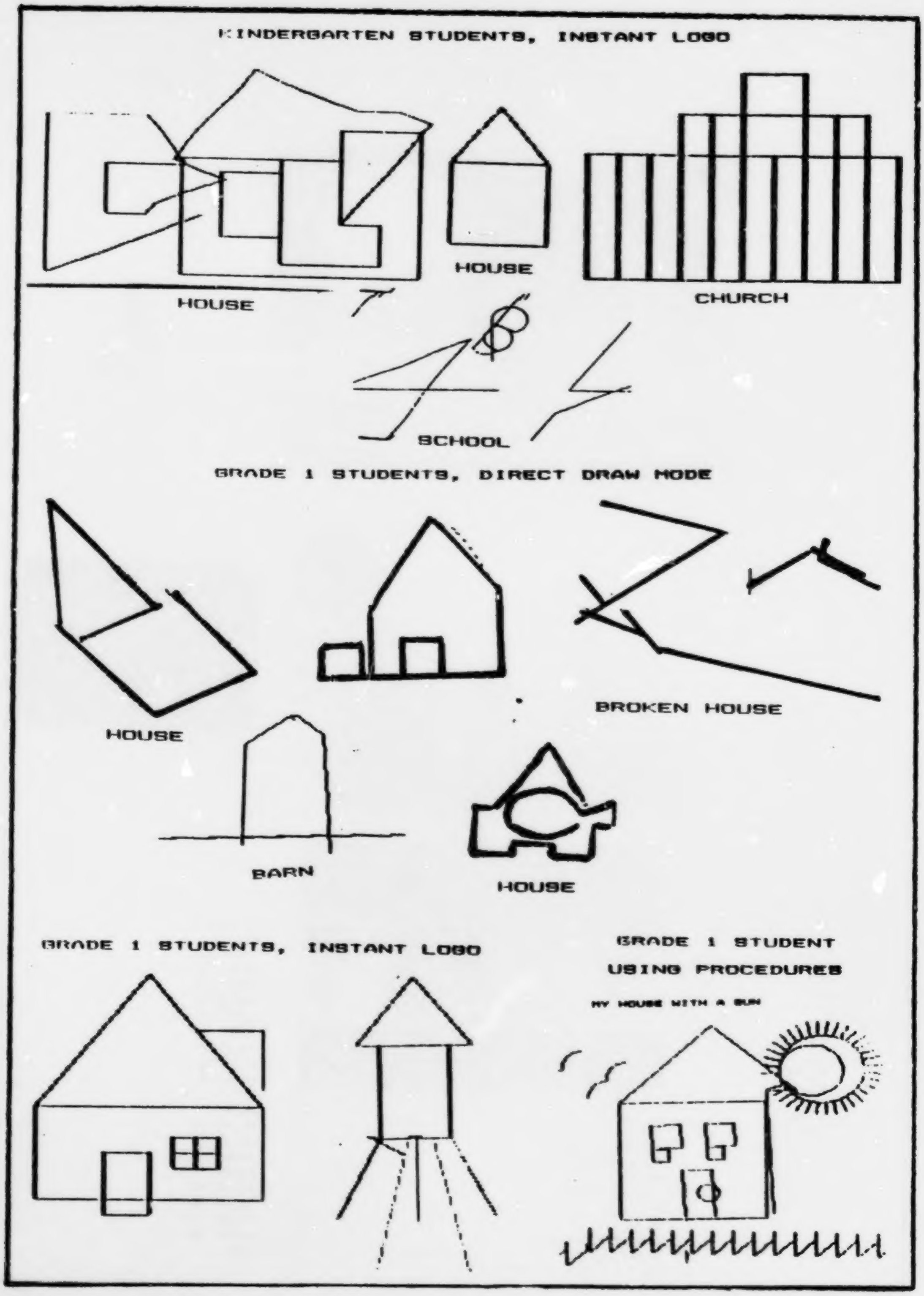
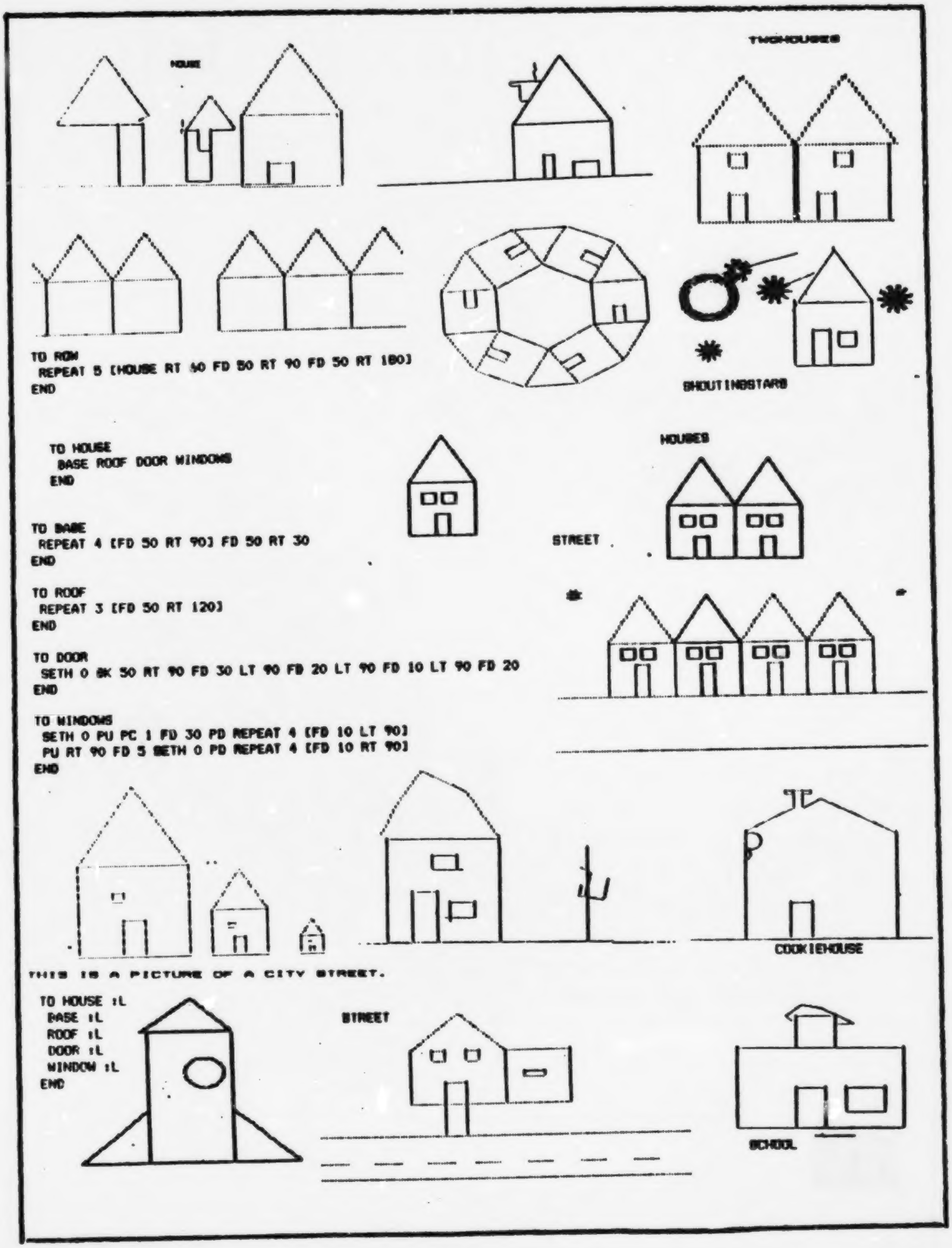

KINDERGARTEN STUDENTS, INSTANT LOGO
HOUSE
HOUSE
CHURCH
SCHOOL
GRADE 1 STUDENTS, DIRECT DRAW MODE
HOUSE
BROKEN HOUSE
BARN
HOUSE
GRADE 1 STUDENTS, INSTANT LOGO
GRADE 1 STUDENT
USING PROCEDURES
MY HOUSE WITH A SUN

Figure 11.45

Some Examples of Houses Drawn by Grade 3 Students Following a Class Lesson on "How to Design a House Using the Procedures 'Square' and 'Triangle' Within a 'House' Procedure"



HOUSE
TWOHOUSES
SHOUTINGSTARS
HOUSES
STREET
COOKIEHOUSE
STREET
SCHOOL

```
TO ROW
 REPEAT 5 [HOUSE RT 60 FD 50 RT 90 FD 50 RT 180]
END
```

```
  TO HOUSE
   BASE ROOF DOOR WINDOWS
  END
```

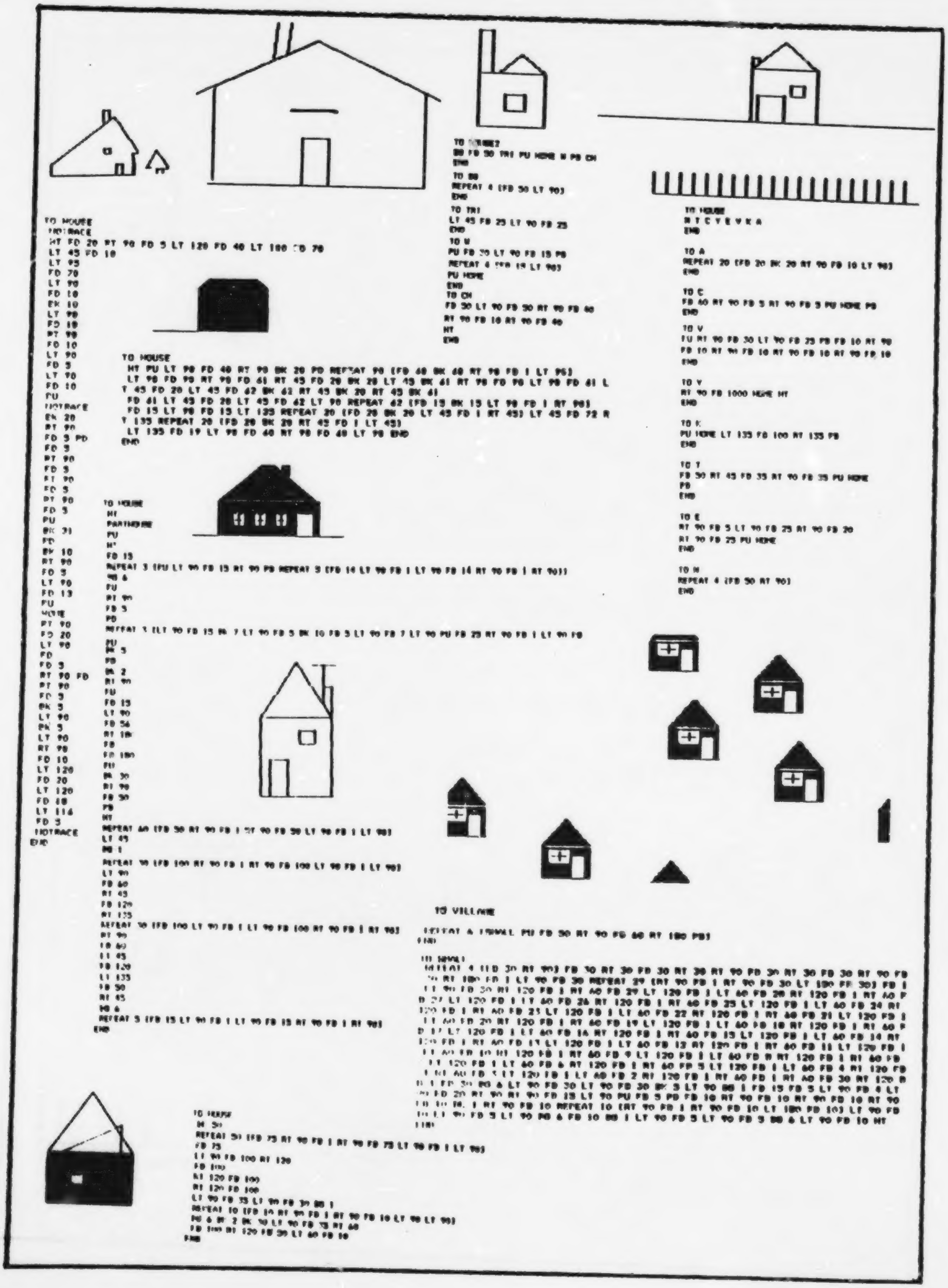
```
TO BASE
 REPEAT 4 [FD 50 RT 90] FD 50 RT 30
END

TO ROOF
 REPEAT 3 [FD 50 RT 120]
END

TO DOOR
 SETH 0 BK 50 RT 90 FD 30 LT 90 FD 20 LT 90 FD 10 LT 90 FD 20
END

TO WINDOWS
 SETH 0 PU PC 1 FD 30 PD REPEAT 4 [FD 10 LT 90]
 PU RT 90 FD 5 SETH 0 PD REPEAT 4 [FD 10 RT 90]
END
```

THIS IS A PICTURE OF A CITY STREET.

```
TO HOUSE :L
 BASE :L
 ROOF :L
 DOOR :L
 WINDOW :L
END
```

Figure 11.46

Some Examples of Houses Drawn by Grade 6, 7, and 8 Students in Response to an Assignment "To Draw a House"



```
TO HOUSE
 NOTRACE
 HT FD 20 RT 90 FD 5 LT 120 FD 40 LT 100 FD 70
 LT 45 FD 10
 LT 95
 FD 70
 LT 90
 FD 10
 BK 10
 LT 90
 FD 10
 RT 90
 FD 10
 LT 90
 FD 5
 LT 90
 FD 10
 PU
 NOTRACE
 BK 20
 RT 90
 FD 5 PD
 FD 5
 RT 90
 FD 5
 RT 90
 FD 5
 RT 90
 FD 5
 PU
 BK 31
 PD
 BK 10
 RT 90
 FD 5
 LT 90
 FD 13
 PU
 HOME
 RT 90
 FD 20
 LT 90
 PD
 FD 5
 RT 90 FD
 RT 90
 FD 5
 BK 5
 LT 90
 BK 5
 LT 90
 RT 90
 FD 10
 LT 120
 FD 20
 LT 120
 FD 10
 LT 114
 FD 5
 NOTRACE
END
```

```
TO [illegible]2
BB FD 50 TRI PU HOME W PD CH
END
TO BB
REPEAT 4 [FD 50 LT 90]
END
TO TRI
LT 45 FD 25 LT 90 FD 25
END
TO W
PU FD 20 LT 90 FD 15 PD
REPEAT 4 [FD 10 LT 90]
PU HOME
END
TO CH
FD 50 LT 90 FD 50 RT 90 FD 40
RT 90 FD 10 RT 90 FD 40
HT
END
```

```
TO HOUSE
 HT PU LT 90 FD 40 RT 90 BK 20 PD REPEAT 90 [FD 40 BK 40 RT 90 FD 1 LT 90]
 LT 90 FD 90 RT 90 FD 41 RT 45 FD 20 BK 20 LT 45 BK 41 RT 90 FD 90 LT 90 FD 41 L
T 45 FD 20 LT 45 FD 62 BK 62 RT 45 BK 20 RT 45 BK 41
 FD 41 LT 45 FD 20 LT 45 FD 62 LT 90 REPEAT 62 [FD 15 BK 15 LT 90 FD 1 RT 90]
 FD 15 LT 90 FD 15 LT 135 REPEAT 20 [FD 20 BK 20 LT 45 FD 1 RT 45] LT 45 FD 72 R
T 135 REPEAT 20 [FD 20 BK 20 RT 45 FD 1 LT 45]
 LT 135 FD 19 LT 90 FD 40 RT 90 FD 40 LT 90 END
END
```

```
TO HOUSE
H T C Y E V K A
END

TO A
REPEAT 20 [FD 20 BK 20 RT 90 FD 10 LT 90]
END

TO C
FD 40 RT 90 FD 5 RT 90 FD 5 PU HOME PD
END

TO V
PU RT 90 FD 30 LT 90 FD 25 PD FD 10 RT 90
FD 10 RT 90 FD 10 RT 90 FD 10 RT 90 FD 10
END

TO Y
RT 90 FD 1000 HOME HT
END

TO K
PU HOME LT 135 FD 100 RT 135 PD
END

TO T
FD 50 RT 45 FD 35 RT 90 FD 35 PU HOME
PD
END

TO E
RT 90 FD 5 LT 90 FD 25 RT 90 FD 20
RT 90 FD 25 PU HOME
END

TO H
REPEAT 4 [FD 50 RT 90]
END
```

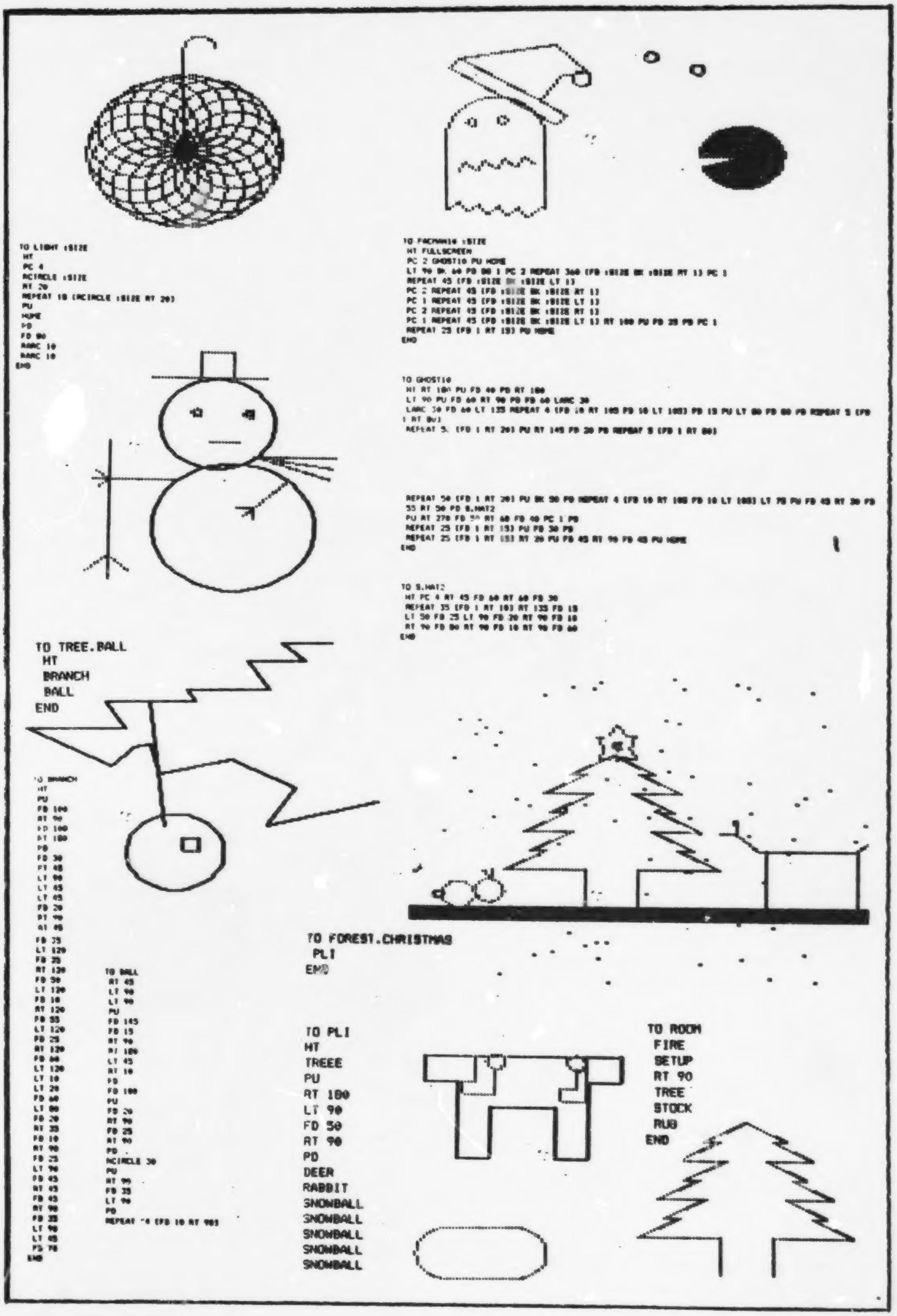
```
TO HOUSE
 HT
 PARTHOME
 PU
 HT
 FD 15
 REPEAT 3 [PU LT 90 FD 15 RT 90 PD REPEAT 5 [FD 14 LT 90 FD 1 LT 90 FD 14 RT 90 FD 1 RT 90]]
 BK 6
 PU
 RT 90
 FD 5
 PD
 REPEAT 3 [LT 90 FD 15 BK 7 LT 90 FD 5 BK 10 FD 5 LT 90 FD 7 LT 90 PU FD 25 RT 90 FD 1 LT 90 PD
 PU
 BK 5
 PD
 BK 2
 RT 90
 PU
 FD 15
 LT 90
 FD 56
 RT 180
 PD
 FD 180
 PU
 BK 30
 RT 90
 FD 50
 PD
 HT
 REPEAT 60 [FD 50 RT 90 FD 1 RT 90 FD 50 LT 90 FD 1 LT 90]
 LT 45
 BK 1
 REPEAT 90 [FD 100 RT 90 FD 1 RT 90 FD 100 LT 90 FD 1 LT 90]
 LT 90
 FD 60
 RT 45
 FD 120
 RT 135
 REPEAT 30 [FD 100 LT 90 FD 1 LT 90 FD 100 RT 90 FD 1 RT 90]
 RT 90
 FD 60
 LT 45
 FD 120
 LT 135
 FD 50
 RT 45
 BK 6
 REPEAT 5 [FD 15 LT 90 FD 1 LT 90 FD 15 RT 90 FD 1 RT 90]
END
```

```
TO VILLAGE
 REPEAT 6 [SMALL PU FD 50 RT 90 FD 60 RT 180 PD]
END

TO SMALL
 REPEAT 4 [FD 30 RT 90] FD 30 RT 30 FD 30 RT 30 RT 90 FD 30 RT 30 FD 30 RT 90 FD
 30 RT 180 FD 1 LT 90 FD 30 REPEAT 29 [RT 90 FD 1 RT 90 FD 30 LT 180 FD 30] FD 1
 LT 90 FD 30 RT 120 FD 1 RT 60 FD 29 LT 120 FD 1 LT 60 FD 28 RT 120 FD 1 RT 60 F
D 27 LT 120 FD 1 LT 60 FD 26 RT 120 FD 1 RT 60 FD 25 LT 120 FD 1 LT 60 FD 24 RT
120 FD 1 RT 60 FD 23 LT 120 FD 1 LT 60 FD 22 RT 120 FD 1 RT 60 FD 21 LT 120 FD 1
 LT 60 FD 20 RT 120 FD 1 RT 60 FD 19 LT 120 FD 1 LT 60 FD 18 RT 120 FD 1 RT 60 F
D 17 LT 120 FD 1 LT 60 FD 16 RT 120 FD 1 RT 60 FD 15 LT 120 FD 1 LT 60 FD 14 RT
120 FD 1 RT 60 FD 13 LT 120 FD 1 LT 60 FD 12 RT 120 FD 1 RT 60 FD 11 LT 120 FD 1
 LT 60 FD 10 RT 120 FD 1 RT 60 FD 9 LT 120 FD 1 LT 60 FD 8 RT 120 FD 1 RT 60 FD
  LT 120 FD 1 LT 60 FD 6 RT 120 FD 1 RT 60 FD 5 LT 120 FD 1 LT 60 FD 4 RT 120 FD
 1 RT 60 FD 3 LT 120 FD 1 LT 60 FD 2 RT 120 FD 1 RT 60 FD 1 RT 60 FD 30 RT 120 F
D 1 FD 30 PD 6 LT 90 FD 30 LT 90 FD 30 BK 3 LT 90 BK 1 FD 15 FD 5 LT 90 FD 4 LT
 90 FD 20 RT 90 RT 90 FD 15 LT 90 PU FD 5 PD FD 10 RT 90 FD 10 RT 90 FD 10 RT 90
 FD 10 RT 90 FD 10 REPEAT 10 [RT 90 FD 1 RT 90 FD 10 LT 180 FD 10] LT 90 FD
 10 LT 90 FD 5 LT 90 PD 6 FD 10 BK 1 LT 90 FD 5 LT 90 FD 5 BK 6 LT 90 FD 10 HT
END
```

```
TO HOUSE
 BK 50
 REPEAT 50 [FD 75 RT 90 FD 1 RT 90 FD 75 LT 90 FD 1 LT 90]
 FD 75
 LT 90 FD 100 RT 120
 FD 100
 RT 120 FD 100
 RT 120 FD 100
 LT 90 FD 35 LT 90 FD 30 BK 1
 REPEAT 10 [FD 10 RT 90 FD 1 RT 90 FD 10 LT 90 LT 90]
 PU 6 RT 2 BK 10 LT 90 FD 75 RT 60
 FD 100 RT 120 FD 30 LT 60 FD 10
END
```

Figure 11.47

Examples of Responses by Grade 5 Students to the Challenge "Design a Christmas Card"



```
TO LIGHT :SIZE
 HT
 PC 4
 RCIRCLE :SIZE
 RT 20
 REPEAT 18 [RCIRCLE :SIZE RT 20]
 PU
 HOME
 PD
 FD 80
 RARC 10
 RARC 10
END
```

```
TO PACMAN10 :SIZE
 HT FULLSCREEN
 PC 2 GHOST10 PU HOME
 LT 90 BK 60 PD BG 1 PC 2 REPEAT 360 [FD :SIZE BK :SIZE RT 1] PC 1
 REPEAT 45 [FD :SIZE BK :SIZE LT 1]
 PC 2 REPEAT 45 [FD :SIZE BK :SIZE RT 1]
 PC 1 REPEAT 45 [FD :SIZE BK :SIZE LT 1]
 PC 2 REPEAT 45 [FD :SIZE BK :SIZE RT 1]
 PC 1 REPEAT 45 [FD :SIZE BK :SIZE LT 1] RT 180 PU FD 25 PD PC 1
 REPEAT 25 [FD 1 RT 15] PU HOME
END
```

```
TO GHOST10
 HT RT 180 PU FD 40 PD RT 180
 LT 90 PU FD 60 RT 90 PD FD 60 LARC 30
 LARC 30 FD 60 LT 135 REPEAT 4 [FD 10 RT 105 FD 10 LT 105] FD 15 PU LT 80 FD 80 PD REPEAT 5 [FD
1 RT 80]
 REPEAT 5 [FD 1 RT 20] PU RT 145 FD 20 PD REPEAT 5 [FD 1 RT 80]
```

```
 REPEAT 50 [FD 1 RT 20] PU BK 50 PD REPEAT 4 [FD 10 RT 105 FD 10 LT 105] LT 75 PU FD 45 RT 30 FD
 55 RT 30 PD S.HAT2
 PU RT 270 FD 50 RT 60 FD 40 PC 1 PD
 REPEAT 25 [FD 1 RT 15] PU FD 30 PD
 REPEAT 25 [FD 1 RT 15] RT 20 PU FD 45 RT 90 FD 45 PU HOME
END
```

```
TO S.HAT2
 HT PC 4 RT 45 FD 60 RT 60 FD 30
 REPEAT 35 [FD 1 RT 10] RT 135 FD 15
 LT 50 FD 25 LT 90 FD 20 RT 90 FD 10
 RT 90 FD 80 RT 90 FD 10 RT 90 FD 60
END
```

```
TO TREE.BALL
 HT
 BRANCH
 BALL
END
```

```
TO BRANCH
 HT
 PU
 FD 100
 RT 90
 FD 100
 RT 180
 PD
 FD 30
 RT 45
 LT 90
 LT 45
 LT 45
 FD 20
 RT 90
 RT 45
 FD 35
 LT 120
 FD 35
 RT 120
 FD 50
 LT 120
 FD 10
 RT 120
 FD 55
 LT 120
 FD 25
 RT 120
 FD 60
 LT 120
 LT 10
 LT 20
 FD 60
 LT 80
 FD 20
 RT 35
 FD 10
 RT 90
 FD 25
 LT 90
 FD 45
 RT 45
 FD 45
 RT 90
 FD 35
 LT 90
 LT 45
 FD 70
END
```

```
TO BALL
 RT 45
 LT 90
 LT 90
 PU
 FD 145
 FD 15
 RT 90
 RT 180
 LT 45
 RT 10
 PD
 FD 100
 PU
 FD 20
 RT 90
 FD 25
 RT 90
 PD .
 RCIRCLE 30
 PU
 RT 95
 FD 35
 LT 90
 PD
 REPEAT "4 [FD 10 RT 90]
```

```
TO FOREST.CHRISTMAS
 PLI
END
```

```
TO PLI
HT
TREEE
PU
RT 180
LT 90
FD 50
RT 90
PD
DEER
RABBIT
SNOWBALL
SNOWBALL
SNOWBALL
SNOWBALL
SNOWBALL
```

```
TO ROOM
 FIRE
 SETUP
 RT 90
 TREE
 STOCK
 RUG
END
```

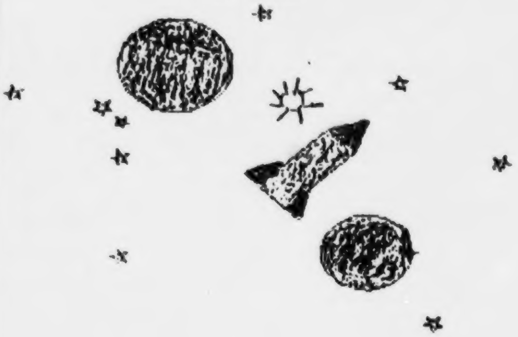
Figure 11.48

Examples of Responses by Grade 3 Students to an Assignment Given During a Science Unit on 'Space' "Design a Space Scene in Turtle Geometry and Write a Story About It on the Bank Street Writer"

The Solar System

The Solar System is a bunch of planets that circle around the sun.The sun is a mass of gases that are pushed together by oxygen.The planets are called Pluto , Jupiter , Saturn , Neptune , Uranus , Mars , Earth , Venus and Mercury.The moon circles around the earth and has many craters in it because of meteors or shooting stars.Many scientists have studied the other planets but mostly the moon because it is the closest to us.We have had many people shot up into space to get more information on the other planets.The planet Pluto we know very,very little about. Scientists have studied one of Jupiters Moons and think that it may have life there.

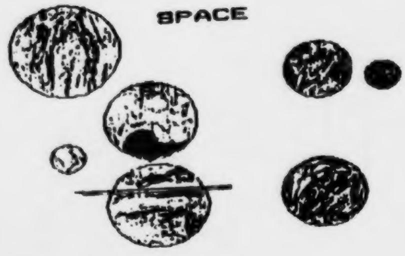
By Irene



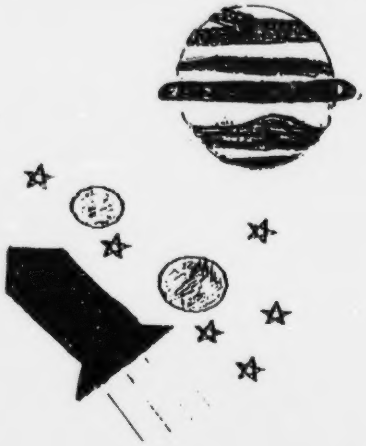
Dreams In Space

One night while I was sleeping I dreamt that I was in outerspace.I was on Saturn.I didn't have any water.I was floating all over the place.Then I saw something green coming toward me.It was a Martian.It spoke a different language.It said that his name was Logray.I thought that was a wierd name.I tried to talk to him in our language,but it wouldn't work.All of a sudden something happened.I knew how to speak his language.All of a sudden I woke up.I found my mom tryint to wake me up.

SPACE



THIS PICTURE WAS HARD TO DO BUT WE MANAGED

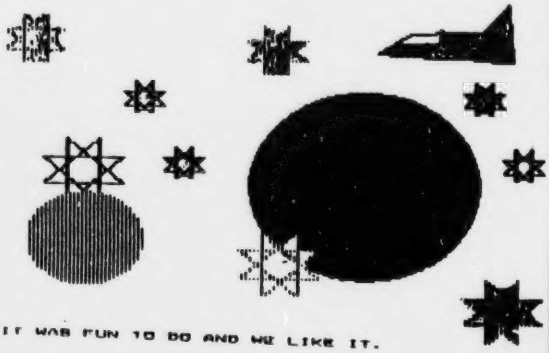


Space

There are a lot of things in Space that an astronaut can do.There are a lot of stars in Space and there are a lot of moving things in Space like planets around the sun and the moon moving around the Earth. There are other planets too,like Venus, Mercury, Jupiter, Mars, Saturn, Neptune, pluto, and Uranus. There is no water on any planets except Earth.

Kathy and Jennifer

SOLAR SYSTEM



IT WAS FUN TO DO AND WE LIKE IT.

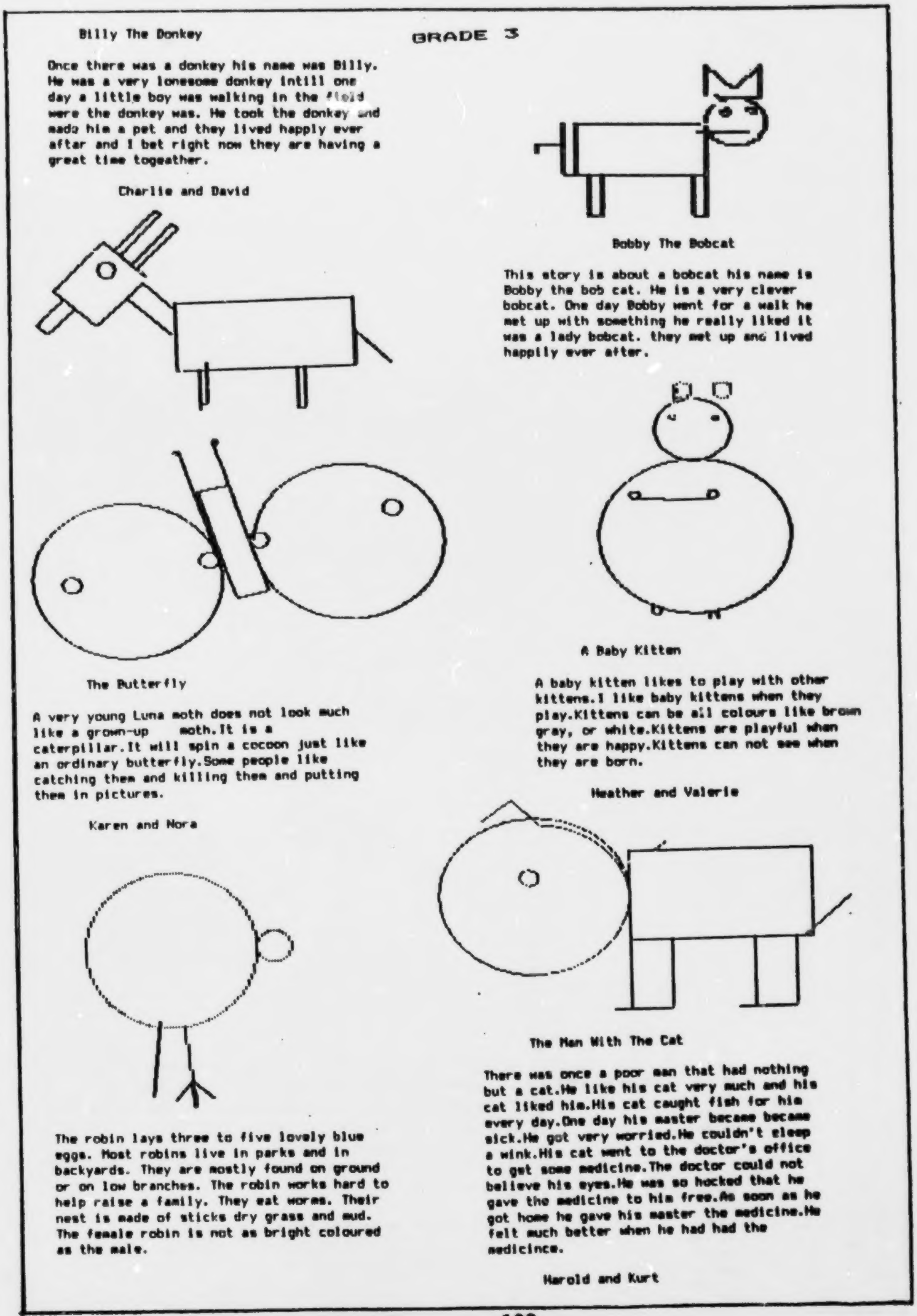
BY SCOTT & TONY

Life On Jupiter

One night a spaceship was returning from the moon when a meteor hit the spaceship and knocked it off course. The man that was flying had to land on Jupiter.When he woke up he saw little men around his ship they had antennae, five arms,and one head.He could not understand what the Martian said.He remembered that he had to get home so he went back to his spaceship and called Earth.A spaceship came to get him.

Figure 11.49

Examples of Responses by Grade 3 Students to an Assignment Given During a Science Unit on 'North American Animals' "Draw an Animal, Bird or Insect That Lives in North America and Write a Story About It"



GRADE 3

Billy The Donkey

Once there was a donkey his name was Billy. He was a very lonesome donkey intill one day a little boy was walking in the field were the donkey was. He took the donkey and made him a pet and they lived happly ever after and I bet right now they are having a great time togeather.

Charlie and David

The Butterfly

A very young Luna moth does not look much like a grown-up moth. It is a caterpillar. It will spin a cocoon just like an ordinary butterfly. Some people like catching them and killing them and putting them in pictures.

Karen and Nora

The robin lays three to five lovely blue eggs. Most robins live in parks and in backyards. They are mostly found on ground or on low branches. The robin works hard to help raise a family. They eat worms. Their nest is made of sticks dry grass and mud. The female robin is not as bright coloured as the male.

Bobby The Bobcat

This story is about a bobcat his name is Bobby the bob cat. He is a very clever bobcat. One day Bobby went for a walk he met up with something he really liked it was a lady bobcat. they met up and lived happily ever after.

A Baby Kitten

A baby kitten likes to play with other kittens. I like baby kittens when they play. Kittens can be all colours like brown gray, or white. Kittens are playful when they are happy. Kittens can not see when they are born.

Heather and Valerie

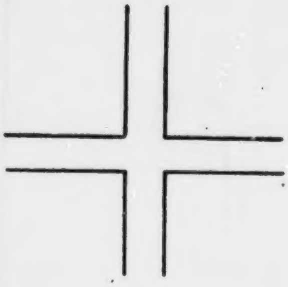
The Man With The Cat

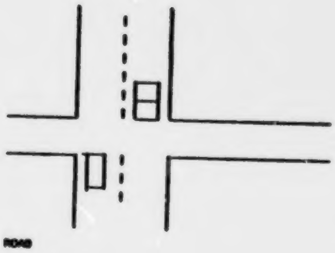
There was once a poor man that had nothing but a cat. He like his cat very much and his cat liked him. His cat caught fish for him every day. One day his master became became sick. He got very worried. He couldn't sleep a wink. His cat went to the doctor's office to get some medicine. The doctor could not believe his eyes. He was so hocked that he gave the medicine to him free. As soon as he got home he gave his master the medicine. He felt much better when he had had the medicince.

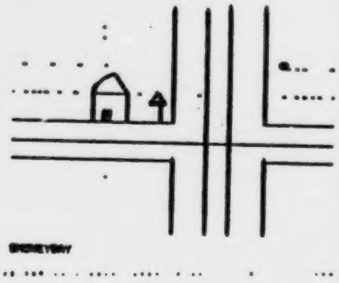
Harold and Kurt

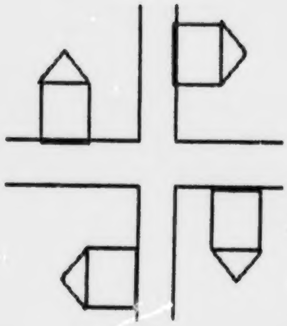
Figure 11.50

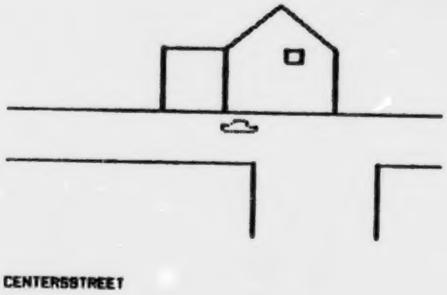
Examples of Explorations by Grade 3 Students Following an Environmental Studies Unit on 'Mapping'





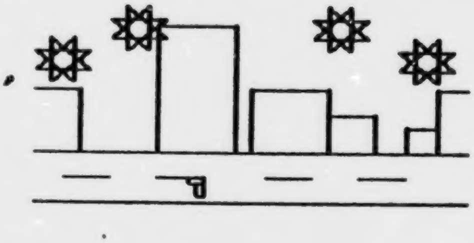






```
TO HOUSE
 REPEAT 4 [FD 40 LT 90]
 FD 40 LT 45 FD 30 LT 90 FD 30
END

TO BLOCK
 FD 110 RT 90 FD 90 RT 90 PU BK 30 RT 90 FD 90 PD BK 90 FD 90 RT 90 FD 90 RT 180 FD 20 RT 90 REP
EAT 4 [BK 40 RT 90] BK 40 RT 45 BK 30 RT 90 BK 30 RT 45 RT 90 PU FD 50 BK 2 FD 30 PD REPEAT 4 [B
K 40 LT 90] BK 40 LT 45 BK 30 RT 90 FD 30 RT 45 PU BK 115 PD RE               PEAT 4 [BK 40 LT
90] BK 40 LT 45 BK 30 LT 90 BK 30 PU RT 45 FD 120 PD REPEAT 4 [FD 40 LT 90] FD 40 LT 45 FD 30 LT
 90 FD 30
END
```

```
TO F                                             FD 550
 FD 50      TO F2      REPEAT 8 [FD 35 RT 135]   RT 90
 RT 90      LT 90 PU   PU                        PU
 FD 50      FD 100     HOME                      FD 20
 RT 90      PD         FD 50                     RT 90
 FD 50      RT 90      RT 90                     PD
 RT 90      FD 50      FD 50                     FD 30
 RT 90      RT 90      LT 90                     PU
 FD 30      FD 50      BK 10                     FD 30
 RT 90      RT 90      FD 40                     PD
 FD 30      FD 50      PD                        FD 30
 RT 90      RT 90      REPEAT 8 [FD 35 RT 135]   PU
 FD 30      FD 50      RT 90                     FD 30
 RT 90      RT 90      PU                        PU
 FD 90      FD 20      FD 50                     FD 30
 RT 90      LT 90      BK 5                      PD
 FD 100     FD 20      PD                        FD 30
 LT 90      LT 90      REPEAT 8 [FD 35 RT 135]   PU
 FD 50      FD 20      PU                        FD 30
 LT 90      LT 90      FD 100                    PD
 FD 100     FD 20      BK 60                     FD 30
 RT 90      BK 200     FD 2                      PU
 FD 50      LT 90      FD 4                      RT 90
 BK 50      PU         PD                        FD 5
 LT 90      FD 100     REPEAT 8 [FD 35 RT 135]   RT 90
 RT 90      BK 20      PU                        PD
 BK 50      PD         HOME                      REPEAT 2 [FD 10 RT 90 FD 5 RT 90 FD 10 RT 90 FD 5]
 FD 50                 RT 180                    HT
 RT 90                 FD 50                     END
END                    BK 10
                       RT 90
                       PD
```

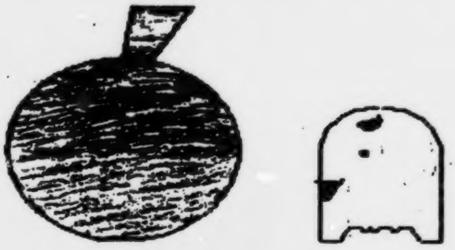


WE WERE JUST THINKING UP A PROCEDURE AND IT TURNED OUT TO BE THIS. (AND IT WAS FUN) FIRST WE THE FIRST PROCEDURE F ANDTHE SECOND PROCEDURE WAS F2.

BY LAURIE AND CHRISTA

Figure 11.51
Extending the Creative Writing and Art Program in Grade 3; Examples From an Assignment "Draw a Picture and Write a Story about Hallowe'en"

HALLOWE'EN



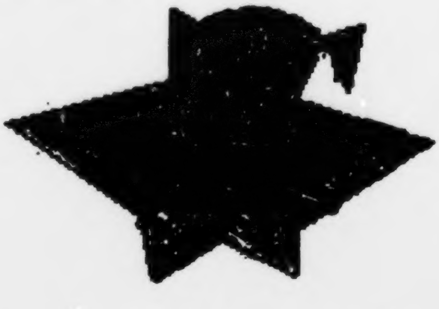
BY BRADMICHAEL

OCTOEER19

Hallowe'en night

On Hallowe'en night the ghost came out to haunt pumpkins.He splattered some and knocked them off the windows and he played baseball with them.When midnight struck Frankenstein chased him away and he was never seen again.

THE BAT



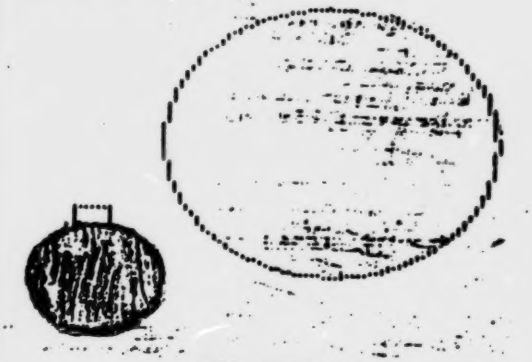
BY TAMMY AND JULIE

OCT 19

The Bat

Once there was a bat he was very kind so I kept him for a pet.I fed him every night.He was so kind he never flew away on me.A few weeks later he was getting bored of always having the same food every night.That morning I went out to check on him and he wasn't there.

MOONANDPUMPKIN



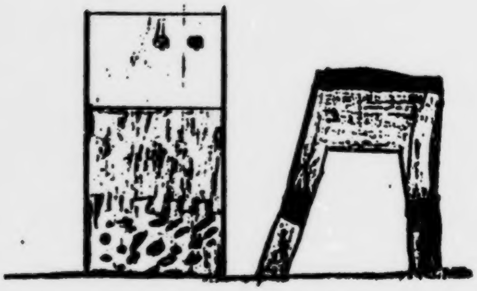
BY JOANNNE KRISTA

OCT 18

The pumpkin and Moon

One night a pumpkin was sitting on a fence. A full moon asked "What is wrong?". The pumpkin said "It's not Hallowe'en yet". The moon was confused he was even sad. The pumpkin was 6 year's old. His father was 66 year's old. His other was 43 year's old. He had no brothers or sisters. The moon was getting smaller and smaller. It was almost daytime when he was asleep.

Ghost



By Laurie Christa.

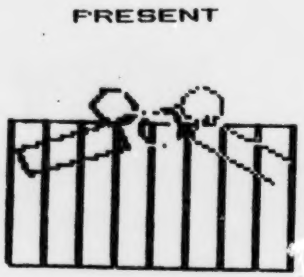
The Ghost.

The ghost was walking down the street and scared himself out of his pants.When he bought himself new pants he ordered a party and had lots of food. Lots of people came to the party. After the party was over, he went out to look at the mess and he cleaned it all up.He started to clean his dirty pants. Then he put his dirty pants on.

Figure 11.52

Extending the Creative Writing and Art Program in Grade 3

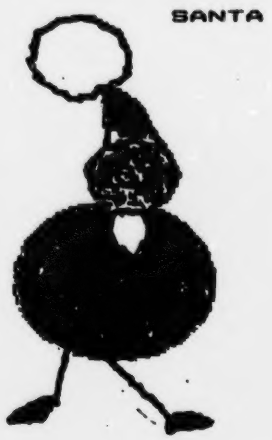
"Draw a Picture and Write a Poem or Story about Christmas"



Christmas Joy

Every day the children are getting more
excited about Christmas.
The children can not wait to see their
presents.
Norman got a big one complained David.
So did you said Norman.
Not as big as yours said David.
Finally Christmas came.
All the kids were happy.

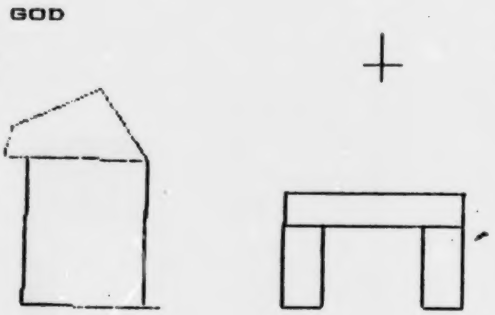
Norman and David
Grade 3



My Christmas Poem

Christmas means lots of fun,
Christmas means lots of baking to be done,
Christmas means lots of snow,
Christmas means the north winds blow,
Christmas means lots of toys,
Christmas means lots of joys.

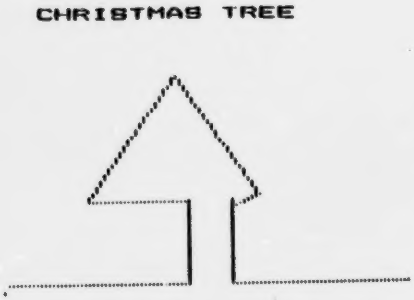
Tommy
Grade 3



What Christmas Means to Me

Hanging up stockings on the fireplace.
Chopping down Christmas trees and putting
decorations on them.
Making Christmas cookies and setting them
by the fireplace.
Eating Christmas cake that my Mom has made.
Getting gifts from people and giving gifts
to them.
Celebrating Jesus' birthday.

Alan
Grade 3



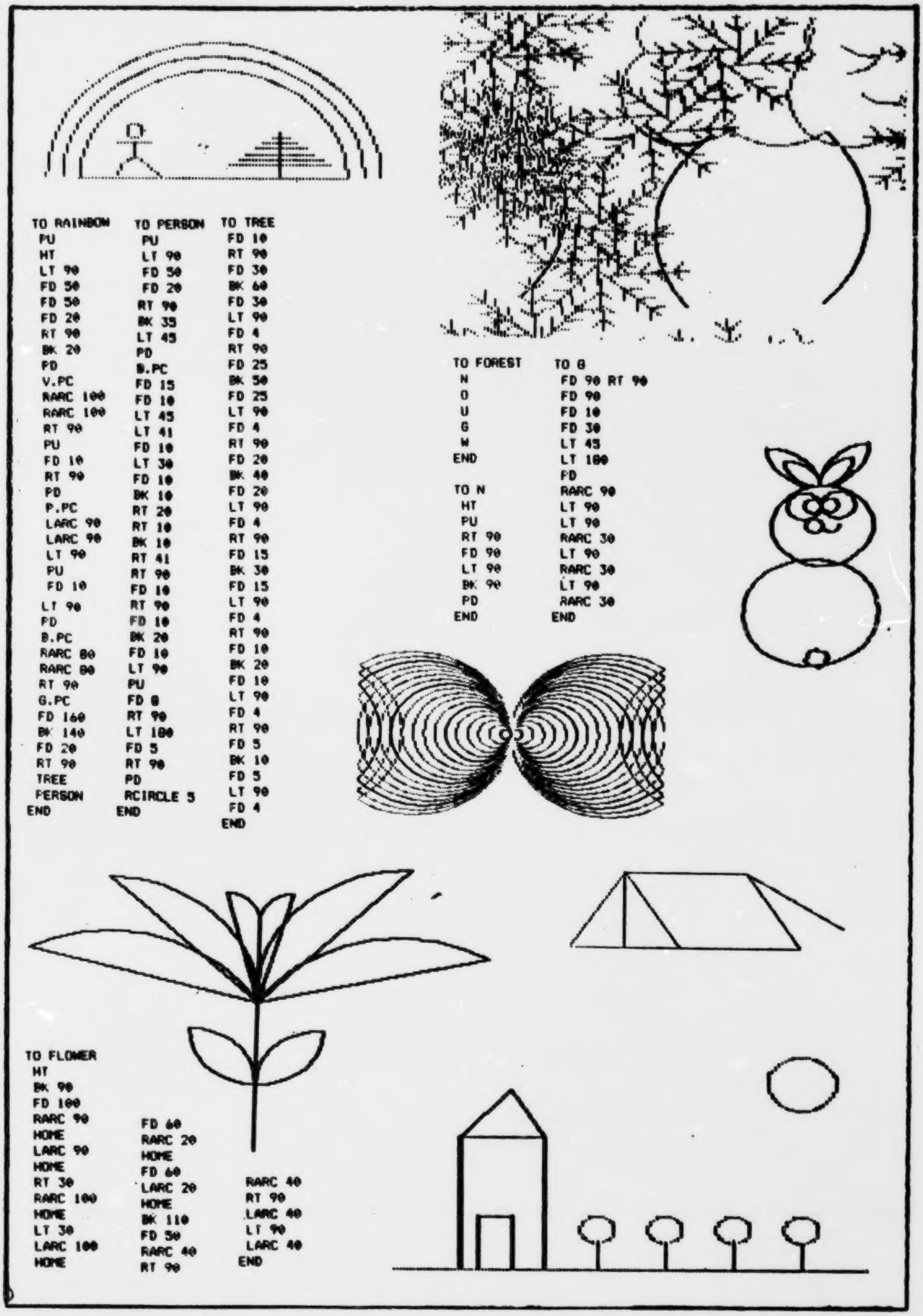
Our Christmas

We went to Almont for dinner we had
turkey and dressing and for dessert we had
icecream and pies..
We played games then we sang Christmas
carols. We went skating then we came
back .We had hotchocolate.Then it was time
to go.

Linda
Grade 3

Figure 11.53

Some Examples of Pictures Created by Grade 5/6 Students in Response to the Challenge "Draw Something Based on the Fieldtrip We Just Had"



```
TO RAINBOW
 PU
 HT
 LT 90
 FD 50
 FD 50
 FD 20
 RT 90
 BK 20
 PD
 V.PC
 RARC 100
 RARC 100
 RT 90
 PU
 FD 10
 RT 90
 PD
 P.PC
 LARC 90
 LARC 90
 LT 90
 PU
 FD 10
 LT 90
 PD
 B.PC
 RARC 80
 RARC 80
 RT 90
 G.PC
 FD 160
 BK 140
 FD 20
 RT 90
 TREE
 PERSON
END
```

```
TO PERSON
 PU
 LT 90
 FD 50
 FD 20
 RT 90
 BK 35
 LT 45
 PD
 B.PC
 FD 15
 FD 10
 LT 45
 LT 41
 FD 10
 LT 30
 FD 10
 BK 10
 RT 20
 RT 10
 BK 10
 RT 41
 RT 90
 FD 10
 RT 90
 FD 10
 BK 20
 FD 10
 LT 90
 PU
 FD 8
 RT 90
 LT 180
 FD 5
 RT 90
 PD
 RCIRCLE 5
END
```

```
TO TREE
 FD 10
 RT 90
 FD 30
 BK 60
 FD 30
 LT 90
 FD 4
 RT 90
 FD 25
 BK 50
 FD 25
 LT 90
 FD 4
 RT 90
 FD 20
 BK 40
 FD 20
 LT 90
 FD 4
 RT 90
 FD 15
 BK 30
 FD 15
 LT 90
 FD 4
 RT 90
 FD 10
 BK 20
 FD 10
 LT 90
 FD 4
 RT 90
 FD 5
 BK 10
 FD 5
 LT 90
 FD 4
END
```

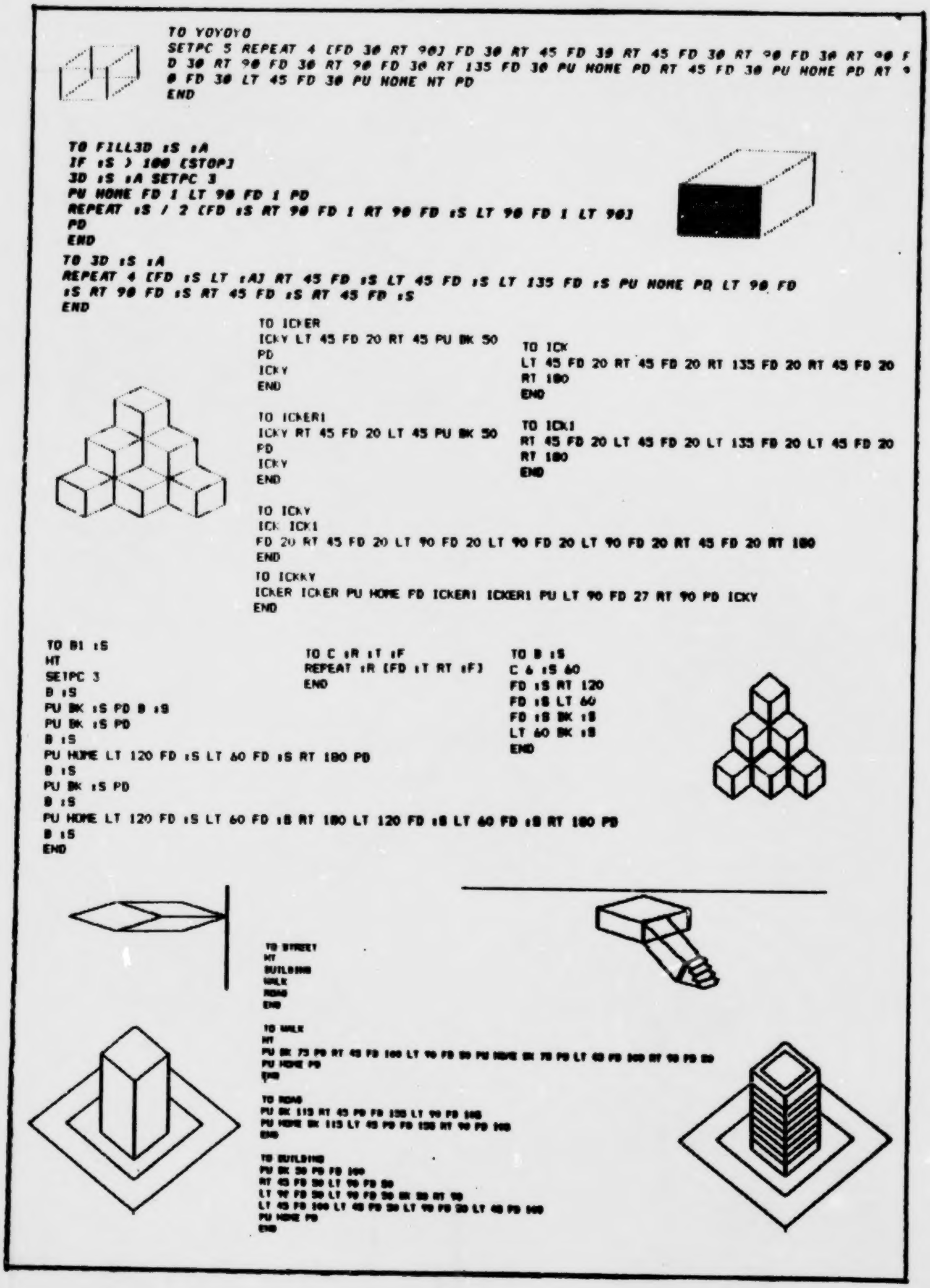
```
TO FOREST
 N
 O
 U
 G
 W
END

TO N
 HT
 PU
 RT 90
 FD 90
 LT 90
 BK 90
 PD
END
```

```
TO G
 FD 90 RT 90
 FD 90
 FD 10
 FD 30
 LT 45
 LT 180
 PD
 RARC 90
 LT 90
 LT 90
 RARC 30
 LT 90
 RARC 30
 LT 90
 RARC 30
END
```

```
TO FLOWER
 HT
 BK 90
 FD 100
 RARC 90
 HOME
 LARC 90
 HOME
 RT 30
 RARC 100
 HOME
 LT 30
 LARC 100
 HOME
 FD 60
 RARC 20
 HOME
 FD 60
 LARC 20
 HOME
 BK 110
 FD 50
 RARC 40
 RT 90
 RARC 40
 RT 90
 LARC 40
 LT 90
 LARC 40
END
```

Figure 11.54

Examples of Perspective Drawings Produced on the Computer by Grade 7 Students During an Art Unit on 'Perspectives'



```
TO YOYOYO
SETPC 5 REPEAT 4 [FD 30 RT 90] FD 30 RT 45 FD 39 RT 45 FD 30 RT 90 FD 30 RT 90 F
D 30 RT 90 FD 30 RT 90 FD 30 RT 135 FD 30 PU HOME PD RT 45 FD 30 PU HOME PD RT 9
0 FD 30 LT 45 FD 30 PU HOME HT PD
END
```

```
TO FILL3D :S :A
IF :S > 100 [STOP]
3D :S :A SETPC 3
PU HOME FD 1 LT 90 FD 1 PD
REPEAT :S / 2 [FD :S RT 90 FD 1 RT 90 FD :S LT 90 FD 1 LT 90]
PD
END
```

```
TO 3D :S :A
REPEAT 4 [FD :S LT :A] RT 45 FD :S LT 45 FD :S LT 135 FD :S PU HOME PD LT 90 FD
:S RT 90 FD :S RT 45 FD :S RT 45 FD :S
END
```

```
TO ICKER
ICKY LT 45 FD 20 RT 45 PU BK 50
PD
ICKY
END
```

```
TO ICK
LT 45 FD 20 RT 45 FD 20 RT 135 FD 20 RT 45 FD 20
RT 180
END
```

```
TO ICKER1
ICKY RT 45 FD 20 LT 45 PU BK 50
PD
ICKY
END
```

```
TO ICK1
RT 45 FD 20 LT 45 FD 20 LT 135 FD 20 LT 45 FD 20
RT 180
END
```

```
TO ICKY
ICK ICK1
FD 20 RT 45 FD 20 LT 90 FD 20 LT 90 FD 20 LT 90 FD 20 RT 45 FD 20 RT 180
END
```

```
TO ICKKY
ICKER ICKER PU HOME FD ICKER1 ICKER1 PU LT 90 FD 27 RT 90 PD ICKY
END
```

```
TO B1 :S
HT
SETPC 3
B :S
PU BK :S PD B :S
PU BK :S PD
B :S
PU HOME LT 120 FD :S LT 60 FD :S RT 180 PD
B :S
PU BK :S PD
B :S
PU HOME LT 120 FD :S LT 60 FD :S RT 180 LT 120 FD :S LT 60 FD :S RT 180 PD
B :S
END
```

```
TO C :R :T :F
REPEAT :R [FD :T RT :F]
END
```

```
TO B :S
C 6 :S 60
FD :S RT 120
FD :S LT 60
FD :S BK :S
LT 60 BK :S
END
```

```
TO STREET
HT
BUILDING
WALK
ROAD
END
```

```
TO WALK
HT
PU BK 75 PD RT 45 FD 100 LT 90 FD 50 PU HOME BK 75 PD LT 45 FD 100 RT 90 FD 50
PU HOME PD
END
```

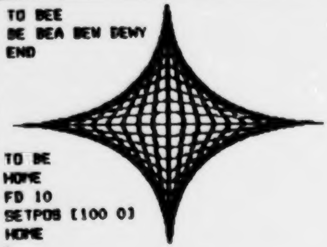
```
TO ROAD
PU BK 113 RT 45 PD FD 150 LT 90 FD 160
PU HOME BK 113 LT 45 PD FD 150 RT 90 FD 160
END
```

```
TO BUILDING
PU BK 30 PD FD 100
RT 45 FD 30 LT 90 FD 30
LT 90 FD 30 LT 90 FD 30 BK 30 RT 90
LT 45 FD 100 LT 45 FD 30 LT 90 FD 30 LT 45 FD 100
PU HOME PD
END
```

Figure 11.55

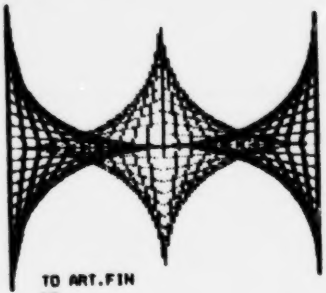
Examples of 'String Art' Designs Produced on the Computer by Grade 7 Students During an Art Unit on 'String Art'

```
TO BEE
BE BEA BEN BEWY
END
```



```
TO BE
HOME
FD 10
SETPOS [100 0]
HOME
L
FD 20
SETPOS [90 0]
HOME L
FD 10
SETPOS [90 0]
HOME
L
FD 30
SETPOS [80 0]
HOME
L
FD 40
SETPOS [70 0]
HOME
L
FD 50
SETPOS [60 0]
HOME
L
FD 60
SETPOS [50 0]
HOME
L
FD 70
SETPOS [40 0]
HOME
L
FD 80
SETPOS [30 0]
HOME
L
FD 90
SETPOS [20 0]
HOME L FD 100
SETPOS [10 0]
END

TO L
SETH 180
END

TO BEA
HOME
FD 10
SETPOS [100 0]
HOME
FD 20
SETPOS [90 0]
HOME
FD 30
SETPOS [80 0]
HOME
FD 40
SETPOS [70 0]
HOME
FD 50
SETPOS [60 0]
HOME
FD 60
SETPOS [50 0]
HOME
FD 70
SETPOS [40 0]
HOME
FD 80
SETPOS [30 0]
HOME
FD 90
SETPOS [20 0]
HOME FD 100
SETPOS [10 0]
END
```

```
TO BEN
HOME
FD 10
SETPOS [-100 0]
HOME
FD 20
SETPOS [-90 0]
HOME
FD 30
SETPOS [-80 0]
HOME
FD 40
SETPOS [-70 0]
HOME
FD 50
SETPOS [-60 0]
HOME
FD 60
SETPOS [-50 0]
HOME
FD 70
SETPOS [-40 0]
HOME
FD 80
SETPOS [-30 0]
HOME
FD 90
SETPOS [-20 0]
HOME FD 100
SETPOS [-10 0]
END

TO BEWY
HOME
L
FD 10
SETPOS [-100 0]
HOME
L
FD 20
SETPOS [-90 0]
HOME
L
FD 30
SETPOS [-80 0]
HOME
L
FD 40
SETPOS [-70 0]
HOME
L
FD 50
SETPOS [-60 0]
HOME
L
FD 60
SETPOS [-50 0]
HOME
L
FD 70
SETPOS [-40 0]
HOME
L
FD 80
SETPOS [-30 0]
HOME
L
FD 90
SETPOS [-20 0]
HOME L FD 100
SETPOS [-10 0]
END
```



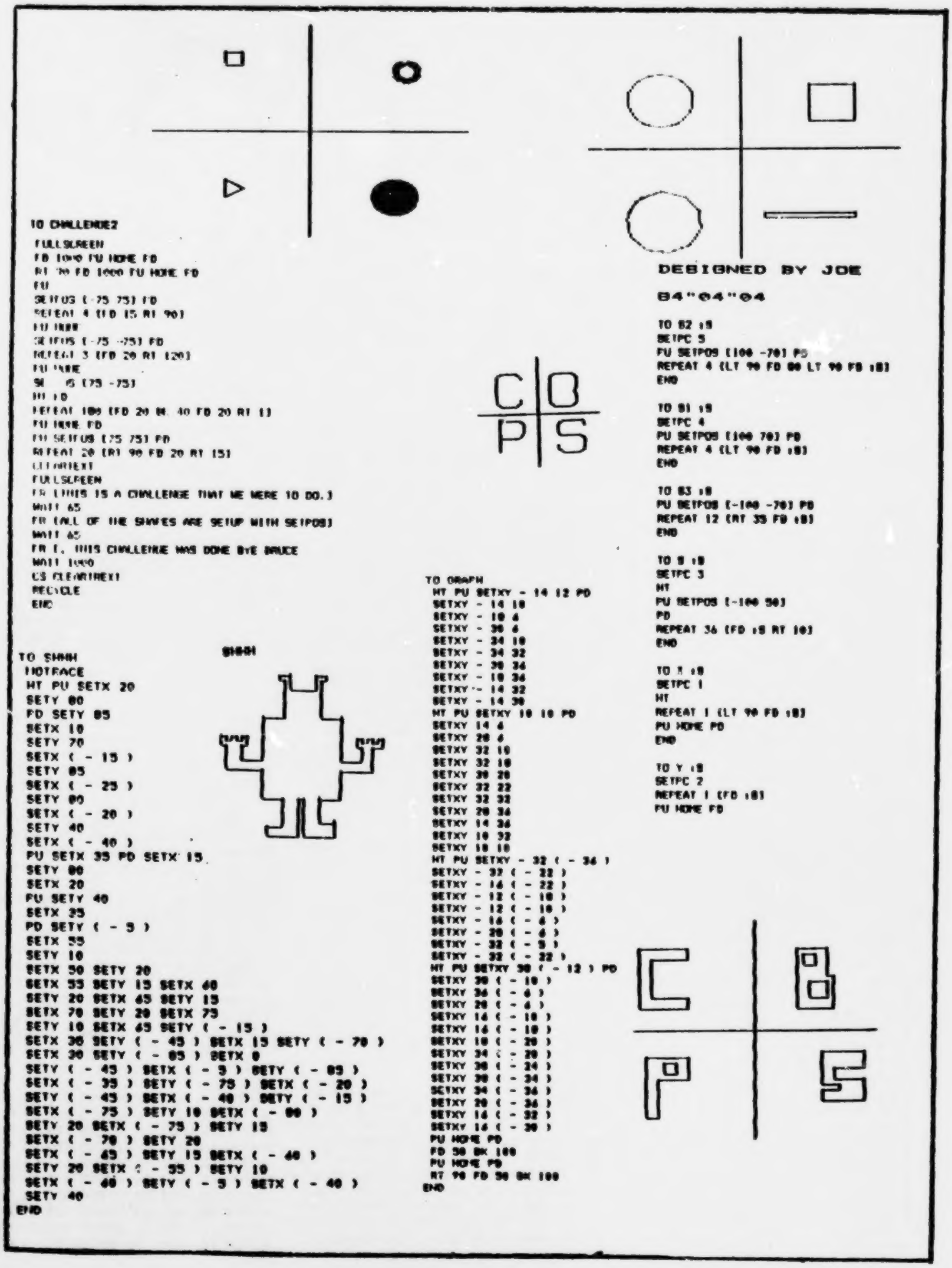
```
TO ART.FIN
CS
HT
ART
PU HOME PD
SETPC 1
ART2
PR [THIS WAS DONE BY CHRISTINE + TANYA
RECYCLE
WAIT 300
CLEARTEXT
CS
END
```

```
TO ART2
PU FD 120 RT 90
FD 120
RT 90
FD 120 BK 120 RT 90 FD 120 RT 180
PU SETPOS [120 0] PU SETPOS [100 120]
PU SETPOS [110 0] PU SETPOS [100 110]
FD SETPOS [100 0] PU SETPOS [100 100]
PD SETPOS [90 0] PU SETPOS [100 90]
PD SETPOS [80 0] PU SETPOS [100 80]
PD SETPOS [70 0] PU SETPOS [100 70]
PD SETPOS [60 0] PU SETPOS [100 60]
PD SETPOS [50 0] PU SETPOS [100 50]
PD SETPOS [40 0] PU SETPOS [100 40]
PD SETPOS [30 0] PU SETPOS [100 30]
PD SETPOS [20 0] PU SETPOS [100 20]
FD SETPOS [10 0] PU SETPOS [100 10]
PD SETPOS [0 0] PU SETPOS [100 0]
PU SETPOS [100 -120]
SETPOS [110 0] PU SETPOS [100 -110]
FD SETPOS [100 0] PU SETPOS [100 -100]
PD SETPOS [90 0] PU SETPOS [100 -90]
PD SETPOS [80 0] PU SETPOS [100 -80]
PD SETPOS [70 0] PU SETPOS [100 -70]
PD SETPOS [60 0] PU SETPOS [100 -60]
PD SETPOS [50 0] PU SETPOS [100 -50]
PD SETPOS [40 0] PU SETPOS [100 -40]
PD SETPOS [30 0] PU SETPOS [100 -30]
FD SETPOS [20 0] PU SETPOS [100 -20]
FD SETPOS [10 0] PU SETPOS [100 -10]
PD SETPOS [0 0]PU SETPOS [100 0]
BK 200
PU SETPOS [-100 120] PD SETPOS [-100 0]
PU SETPOS [-100 110] SETPOS [-90 0]
PD SETPOS [-100 100] SETPOS [-80 0]
FD SETPOS [-100 90] PU SETPOS [-70 0]
FD SETPOS [-100 80] PU SETPOS [-60 0]
PD SETPOS [-100 70] PU SETPOS [-50 0]
PD SETPOS [-100 60] PU SETPOS [-40 0]
PD SETPOS [-100 50] PU SETPOS [-30 0]
FD SETPOS [-100 40] PU SETPOS [-20 0]
PD SETPOS [-100 30] PU SETPOS [-10 0]
PD SETPOS [-100 20] PU SETPOS [0 0]
FD SETPOS [-100 10] PU SETPOS [10 0]
PD SETPOS [-100 0] PU SETPOS [20 0]
PD BK 120
RT 90 FD 100
FD SETPOS [-100 -120] SETPOS [-90 0]
PD SETPOS [-100 -110] SETPOS [-80 0]
FD SETPOS [-100 -100] PU SETPOS [-70 0]
FD SETPOS [-100 -90] PU SETPOS [-60 0]
PD SETPOS [-100 -80] PU SETPOS [-50 0]
PD SETPOS [-100 -70] PU SETPOS [-40 0]
PD SETPOS [-100 -60] PU SETPOS [-30 0]
PD SETPOS [-100 -50] PU SETPOS [-20 0]
PD SETPOS [-100 -40] PU SETPOS [-10 0]
PD SETPOS [-100 -30] PU SETPOS [0 0]
PD SETPOS [-100 -20] PU SETPOS [10 0]
PD SETPOS [-100 -10] PU SETPOS [20 0]
FD SETPOS [-100 0] PU SETPOS [30 0]
END
```

```
TO ART
FD 100 BK 200
FD 100 RT 90 FD 100 BK 200
SETPC 5
SETPOS [0 10] PU SETPOS [-90 0] PD
SETPOS [0 20] PU SETPOS [-80 0] PD
SETPOS [0 30] PU SETPOS [-70 0] PD
SETPOS [0 40] PU SETPOS [-60 0] PD
SETPOS [0 50] PU SETPOS [-50 0] PD
SETPOS [0 60] PU SETPOS [-40 0] PD
SETPOS [0 70] PU SETPOS [-30 0] PD
SETPOS [0 80] PU SETPOS [-20 0] PD
SETPOS [0 90] PU SETPOS [-10 0] PD
SETPOS [0 100] PU SETPOS [0 0] PD
FD 100 RT 180
SETPC 3
SETPOS [0 10] PU SETPOS [90 0] PD
SETPOS [0 20] PU SETPOS [80 0] PD
SETPOS [0 30] PU SETPOS [70 0] PD
SETPOS [0 40] PU SETPOS [60 0] PD
SETPOS [0 50] PU SETPOS [50 0] PD
SETPOS [0 60] PU SETPOS [40 0] PD
SETPOS [0 70] PU SETPOS [30 0] PD
SETPOS [0 80] PU SETPOS [20 0] PD
SETPOS [0 90] PU SETPOS [10 0] PD
SETPOS [0 100] PU SETPOS [0 0] PD
SETPOS [0 100]
PD SETPOS [0 -10] SETPOS [-90 0] PD
SETPOS [0 -20] PU SETPOS [-80 0] PD
SETPOS [0 -30] PU SETPOS [-70 0] PD
SETPOS [0 -40] PU SETPOS [-60 0] PD
SETPOS [0 -50] PU SETPOS [-50 0] PD
SETPOS [0 -60] PU SETPOS [-40 0] PD
SETPOS [0 -70] PU SETPOS [-30 0] PD
SETPOS [0 -80] PU SETPOS [-20 0] PD
SETPOS [0 -90] PU SETPOS [-10 0] PD
SETPOS [0 -100] PU SETPOS [0 0] PD
BK 100
SETPC 5
SETPOS [0 -10] PU SETPOS [90 0] PD
SETPOS [0 -20] PU SETPOS [80 0] PD
SETPOS [0 -30] PU SETPOS [70 0] PD
SETPOS [0 -40] PU SETPOS [60 0] PD
SETPOS [0 -50] PU SETPOS [50 0] PD
SETPOS [0 -60] PU SETPOS [40 0] PD
SETPOS [0 -70] PU SETPOS [30 0] PD
SETPOS [0 -80] PU SETPOS [20 0] PD
SETPOS [0 -90] PU SETPOS [10 0] PD
SETPOS [0 -100] PU SETPOS [0 0] PD
END
```

Figure 11.56

Examples of Responses by Grade 7 and 8 Students to an Assignment "Place Shapes or Letters in the Four Quadrants of a Graph or Make a Design Using the SETXY Primitive of Logo"



```
TO CHALLENGE2
 FULLSCREEN
 FD 1000 PU HOME PD
 RT 90 FD 1000 PU HOME PD
 PU
 SETPOS [-75 75] PD
 REPEAT 4 [FD 15 RT 90]
 PU HOME
 SETPOS [-75 -75] PD
 REPEAT 3 [FD 20 RT 120]
 PU HOME
 SE   S [75 -75]
 HT PD
 REPEAT 180 [FD 20 BK 40 FD 20 RT 1]
 PU HOME PD
 PU SETPOS [75 75] PD
 REPEAT 20 [RT 90 FD 20 RT 15]
 CLEARTEXT
 FULLSCREEN
 PR [THIS IS A CHALLENGE THAT WE WERE TO DO.]
 WAIT 65
 PR [ALL OF THE SHAPES ARE SETUP WITH SETPOS]
 WAIT 65
 PR [. THIS CHALLEIRE WAS DONE BYE BRUCE
 WAIT 1000
 CS CLEARTEXT
 RECYCLE
 END
```

```
TO SHHH
 NOTRACE
 HT PU SETX 20
 SETY 80
 PD SETY 85
 SETX 10
 SETY 70
 SETX ( - 15 )
 SETY 85
 SETX ( - 25 )
 SETY 80
 SETX ( - 20 )
 SETY 40
 SETX ( - 40 )
 PU SETX 35 PD SETX 15
 SETY 80
 SETX 20
 PU SETY 40
 SETX 35
 PD SETY ( - 5 )
 SETX 55
 SETY 10
 SETX 50 SETY 20
 SETX 55 SETY 15 SETX 60
 SETY 20 SETX 65 SETY 15
 SETX 70 SETY 20 SETX 75
 SETY 10 SETX 65 SETY ( - 15 )
 SETX 30 SETY ( - 45 ) SETX 15 SETY ( - 70 )
 SETX 30 SETY ( - 85 ) SETX 0
 SETY ( - 45 ) SETX ( - 5 ) SETY ( - 85 )
 SETX ( - 35 ) SETY ( - 75 ) SETX ( - 20 )
 SETY ( - 45 ) SETX ( - 40 ) SETY ( - 15 )
 SETX ( - 75 ) SETY 10 SETX ( - 80 )
 SETY 20 SETX ( - 75 ) SETY 15
 SETX ( - 70 ) SETY 20
 SETX ( - 65 ) SETY 15 SETX ( - 60 )
 SETY 20 SETX ( - 55 ) SETY 10
 SETX ( - 60 ) SETY ( - 5 ) SETX ( - 40 )
 SETY 40
END
```

```
TO GRAPH
 HT PU SETXY - 14 12 PD
 SETXY - 14 10
 SETXY - 10 6
 SETXY - 30 6
 SETXY - 34 10
 SETXY - 34 32
 SETXY - 30 36
 SETXY - 10 36
 SETXY - 14 32
 SETXY - 14 30
 HT PU SETXY 10 10 PD
 SETXY 14 6
 SETXY 28 6
 SETXY 32 10
 SETXY 32 18
 SETXY 30 20
 SETXY 32 22
 SETXY 32 32
 SETXY 28 36
 SETXY 14 36
 SETXY 10 32
 SETXY 10 10
 HT PU SETXY - 32 ( - 36 )
 SETXY - 32 ( - 22 )
 SETXY - 16 ( - 22 )
 SETXY - 12 ( - 18 )
 SETXY - 12 ( - 10 )
 SETXY - 16 ( - 6 )
 SETXY - 20 ( - 6 )
 SETXY - 32 ( - 5 )
 SETXY - 32 ( - 22 )
 HT PU SETXY 30 ( - 12 ) PD
 SETXY 30 ( - 10 )
 SETXY 36 ( - 6 )
 SETXY 20 ( - 6 )
 SETXY 14 ( - 10 )
 SETXY 16 ( - 18 )
 SETXY 18 ( - 20 )
 SETXY 34 ( - 20 )
 SETXY 38 ( - 24 )
 SETXY 38 ( - 34 )
 SETXY 34 ( - 36 )
 SETXY 20 ( - 36 )
 SETXY 16 ( - 32 )
 SETXY 16 ( - 30 )
 PU HOME PD
 FD 50 BK 100
 PU HOME PD
 RT 90 FD 50 BK 100
END
```

DESIGNED BY JOE

84"04"04

```
TO B2 :S
SETPC 5
PU SETPOS [100 -70] PD
REPEAT 4 [LT 90 FD 80 LT 90 FD :S]
END

TO B1 :S
SETPC 4
PU SETPOS [100 70] PD
REPEAT 4 [LT 90 FD :S]
END

TO B3 :S
PU SETPOS [-100 -70] PD
REPEAT 12 [RT 35 FD :S]
END

TO B :S
SETPC 3
HT
PU SETPOS [-100 50]
PD
REPEAT 36 [FD :S RT 10]
END

TO X :S
SETPC 1
HT
REPEAT 1 [LT 90 FD :S]
PU HOME PD
END

TO Y :S
SETPC 2
REPEAT 1 [FD :S]
PU HOME PD
```

12. LOGO SPRITES

At the outset of the study, sprites (multiple moving objects or "turtles" whose colour, speed, and direction can be changed simultaneously) were only available on the TEXAS INSTRUMENTs' version of Logo which was being used in a Grade 1 setting (sites 2a and 2b). The original intent was to examine the effect of combining turtle geometry with the capabilities of the sprites. However, the TI version that was available at that time did not have enough memory to use both simultaneously. "Out of ink" screen messages were very frequent and students quickly learned that the TEXAS INSTRUMENTS computer could be used for one of Logo or sprites but not both. Since students also had access to Logo on an APPLE II+, they tended to use the TI for sprites and the APPLE II+ for Logo. Although an upgraded version of TI Logo with larger memory had been ordered from the outset, it did not arrive until late in the second year of the study.

During the second year, a COMMODORE 64 and an ATARI 800 were used in one of the settings (site 8b,ab). The Logo version for both of these machines had sprites as an integral part of the implementation. Students at this site experimented with some of the sprite features. The full version of Sprite Logo for the APPLE based on LCSI Logo did not become available until the late spring of 1984. At this point of the school-year, teachers were reluctant to incorporate anything new into their classroom without extensive support from the research team. Since sprites made it easy to incorporate animation into turtle graphics, the research team felt that it was desirable to obtain some information on this extended use of Logo even if it meant deviating from the original research design. It was therefore decided to engage a recent Masters of Education graduate who had extensive programming experience, and who was familiar with LCSI sprites to work in one of the classrooms (site 6b,ab) for one month, and to act as instructor and researcher during that time. She worked with students at the computer, assisted them with problems, and offered them ideas for possible activities. Her findings on the use of LCSI sprites with Grade 5/6 students are presented in this section.

SPRITES: TI, C64, ATARI

During the first year of the study, the students in Grade 1 received a class lesson on the use of sprites, and additional support was given by means of instruction and idea cards placed by the computer. Over a period of six weeks, many of these students were able to move several sprites simultaneously and to create their own animated scenes. A few students had progressed to modifying given sprites or designing their own sprite-shapes. Students who were able to modify given sprites thought it "neat" that they could change a "given". One of the students, for example, modified a rocket by placing fuel pipes from the wings into the rocket. Humour was often an integral part of these activities: for example, two students made "trees" out of brown rectangles and green balls. They then alternately "chopped the heads off" or "knocked the trunks from under the tops" by sending the appropriate parts in different directions which amused them greatly. Dialogue and imaginative stories were a common by-product of sprite activities. Many students experienced some difficulty with the use of numbers for both the pre-programmed shapes and the available sprites. Instructions such as "sprite 1 carrying shape 8" tended to be confusing.

During the second year of the study, the Grade 7 students had access to sprites on a COMMODORE 64 and an ATARI 800. Unfortunately, the teacher did not have time to "teach" about the special features of these two machines; hence, they were used sparingly by the students. The teacher did set a few challenges, such as: "Write a program, using four different turtle shapes, that runs four different activities on the screen at one time". However, only the more adventuresome boys responded. Two such boys turned this challenge into an animated PACMAN scenario. Other explorations by a few boys included making a target game using the joystick, a skateboarder jumping over a ramp, and a FROGGER-type game.

SPRITES: LCSI

Sprite Logo, which was explored in the Grade 5/6 classroom for only one month, generated much enthusiasm among students. Two sprite circuit boards were available, permitting approximately half of the class to use them for thirty minutes each day. The students involved were all experienced Logo users; they had all been using Terrapin Logo in the classroom during the school year, and the Grade 6 students also were familiar with LCSI Logo which they had used the previous year. The interest among students remained high for all Sprite Logo sessions. The features that appeared to attract the greatest use and interest were the STAMP, SETSHAPE, and SETSPEED commands.

Using SETSHAPE, the students could direct any of the thirty turtles to take on predefined shapes which initially set off an investigation into the nature of these shapes. Comments such as "Oh, neat!" or "Excellent!" were common. This investigation ignited their imaginations, and they quickly wanted to create their own animated figures by making use of the shape editor. Students created sprites that were elephants, army tanks, and frogs, among others. They often spent time just watching their newly created shapes move by using the SETSPEED command. Fast moving sprites were of particular interest and students appreciated the ease with which they could actually make their own shapes move around the screen.

Sprite Logo, which has all the "standard" Logo commands embedded in it, heightened students' interest in Logo and opened many more possibilities for exploration and projects. Several students who had become bored with turtle geometry expressed new interest since there were "so many more things to do" with Sprite Logo. The ease with which movement could be produced brought their projects closer to the "real" world and generated great excitement.

When students were working on their own tasks, rather than on teacher-directed tasks, boys emerged as the game-makers and the girls as the design-makers. The boys were more likely to use moving sprites to make arcade-style games of the "shoot-them-up" variety. Some of the boys completed or almost completed such games within a few sessions. Only one of the girls designed and completed an action game. Most of the girls spent considerable time making colourful designs and interesting patterns that were created by letting the many moving turtles leave trails on the screen. They often used the STAMP command to leave imprints of the turtle shapes on the screen as they moved about. This created interesting and visually pleasing designs.

There were some problems that were inherent in the Sprite Logo implementation, but most of the difficulties encountered by students dealt with finding appropriate programming and problem-solving strategies which would allow them to actualize their ideas in that medium. The tasks initially undertaken by the students were fairly straightforward, but with time they wanted to work on ideas that were beyond their current programming abilities. Using sprites can look deceptively easy; however, a fair degree of programming sophistication is required for even some "simple" ideas. Students definitely needed help in acquiring the necessary programming skills and in assisting them in their "debugging" phase.

13. KOALA PAD GRAPHICS

The Koala Pad belongs to the genre of graphic tablets on which one can create designs either by using shapes from a preset menu or by moving a blunt instrument or finger on the tablet. The Grade 1 teacher found that her students pressed too hard and wore out the surface when they were using the tapered wooden stick that came with the package, so suggested that they use their fingers only. In this class a typical student reaction to the Koala was:

> You don't have to type and you can draw lots of nice pictures with lots of colours. (Feb. 2/84)

Making artistic designs with the Koala Pad is analogous to drawing or painting, with the additional feature that one has an electronic template for a few colours, and preset shapes, such as circles, squares, rectangles. Since erasing is relatively easy, it facilitates extensive exploration and experimentation without always having to start all over again.

One of the interesting distinctions between using the Logo language and the Koala Pad for graphics, is that Logo demands that the task be analyzed within the structure of the Logo language and then executed. This process, in an artistic sense, is considerably removed from a "natural" process. Using the Koala Pad allows a more direct translation of the artistic thought into form. The desire to place a blue circle "there" can be executed within a minute, whereas within Logo this process takes considerably longer. For example, compare two snowmen: one done by a Grade 1 student on the Koala Pad (Figure 13.1), and one done by a pair of Grade 7 students using Logo (Figure 13.2). The one on the Koala Pad was done in approximately twenty minutes and the one done in Logo occupied these students off and on for three months. The level of knowledge of the Logo syntax and programming skills required for creating the snowman design were quite extensive (Figure 13.3). These students did not mind the time involved since their main objective was to do "something" during their assigned computer-time. They had the following to say about their picture:

> We liked what we were doing because we finished our snowman. We think we have finally finished it as far as we can go with additions. It was pretty nice to see it done because we started in November. (Feb. 10/84)

Figure 13.1

Some Examples of Pictures Created by Grade 1 Students

With the Koala Pad

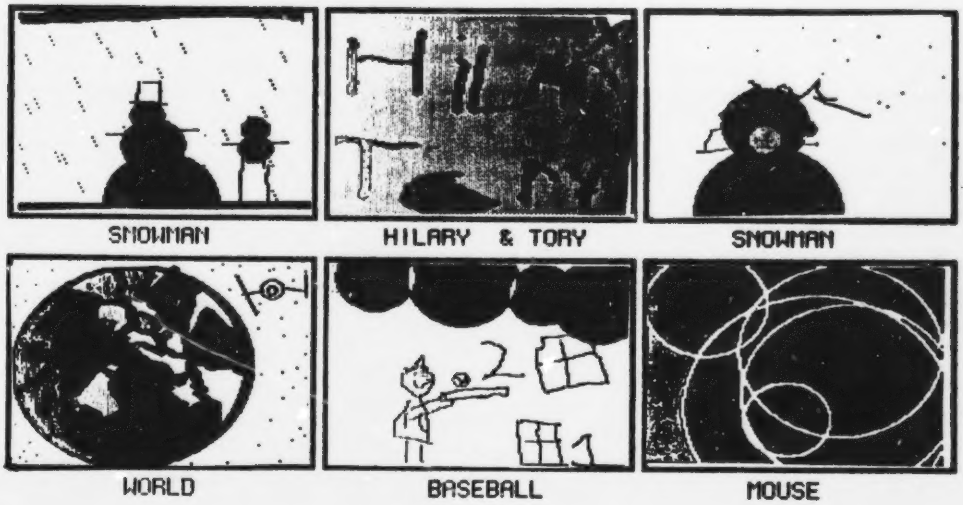

SNOWMAN
HILARY & TORY
SNOWMAN
WORLD
BASEBALL
MOUSE

Figure 13.2

A Picture of a Snowman Created by Two Grade 7 Students

Using Logo

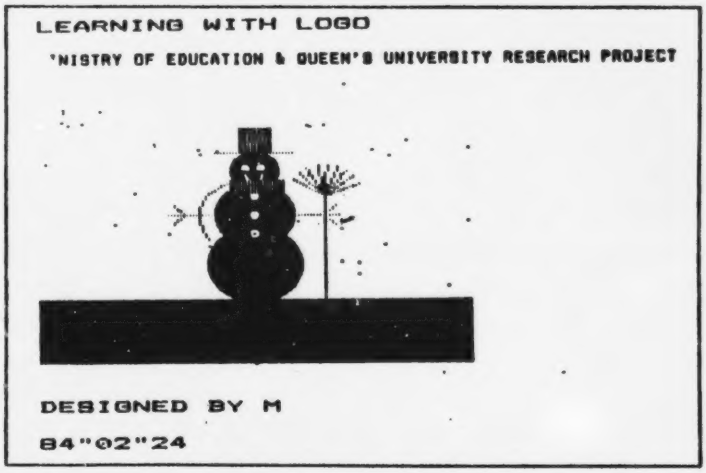
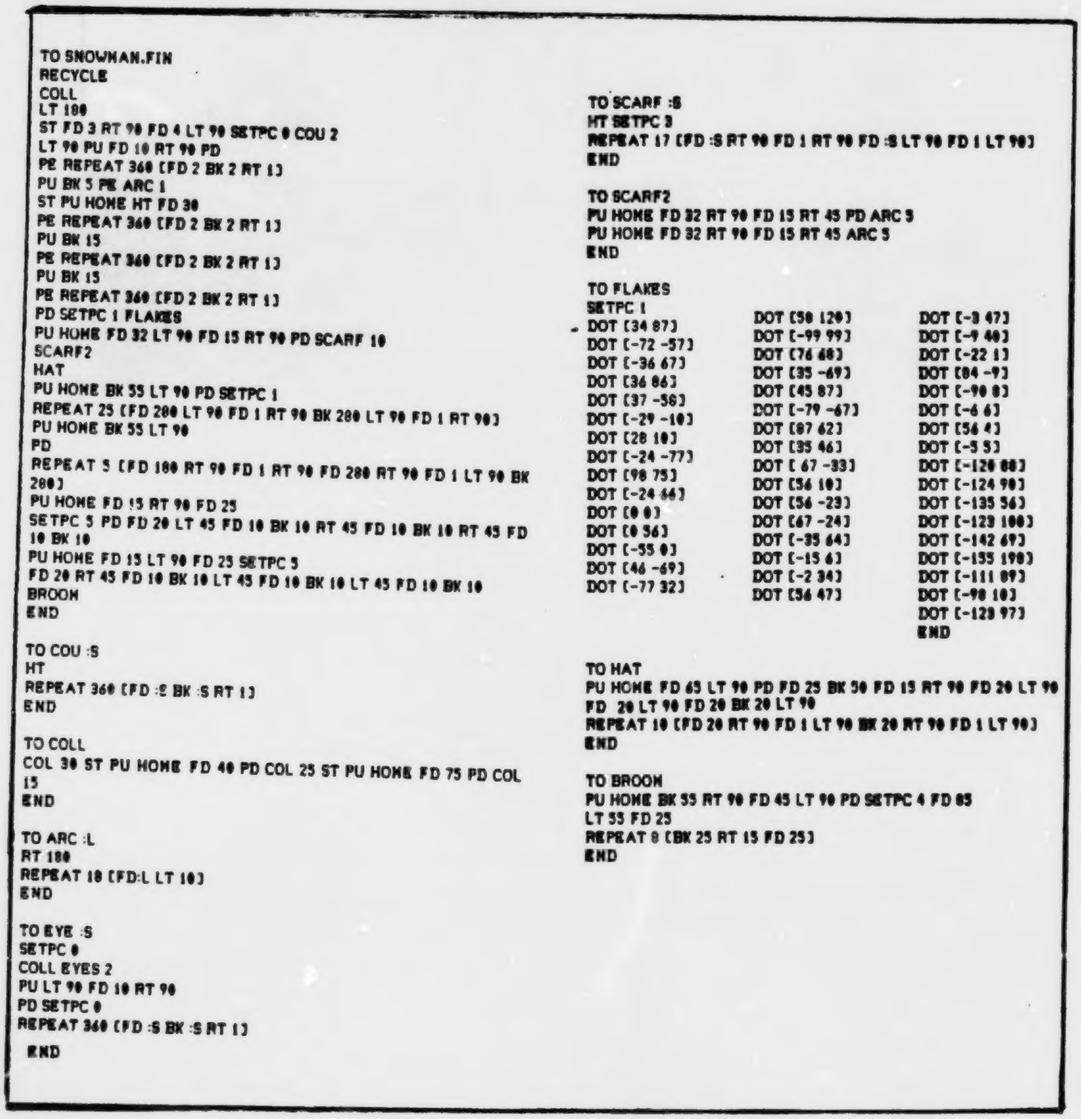

LEARNING WITH LOGO
'NISTRY OF EDUCATION & QUEEN'S UNIVERSITY RESEARCH PROJECT
DESIGNED BY M
84"02"24

Figure 13.3

Logo Procedure Used to Make the Snowman Depicted in Figure 13.2



```
TO SNOWMAN.FIN
RECYCLE
COLL
LT 180
ST FD 3 RT 90 FD 4 LT 90 SETPC 0 COU 2
LT 90 PU FD 10 RT 90 PD
PE REPEAT 360 [FD 2 BK 2 RT 1]
PU BK 5 PE ARC 1
ST PU HOME HT FD 30
PE REPEAT 360 [FD 2 BK 2 RT 1]
PU BK 15
PE REPEAT 360 [FD 2 BK 2 RT 1]
PU BK 15
PE REPEAT 360 [FD 2 BK 2 RT 1]
PD SETPC 1 FLAKES
PU HOME FD 32 LT 90 FD 15 RT 90 PD SCARF 10
SCARF2
HAT
PU HOME BK 55 LT 90 PD SETPC 1
REPEAT 25 [FD 200 LT 90 FD 1 RT 90 BK 200 LT 90 FD 1 RT 90]
PU HOME BK 55 LT 90
PD
REPEAT 5 [FD 100 RT 90 FD 1 RT 90 FD 200 RT 90 FD 1 LT 90 BK
200]
PU HOME FD 15 RT 90 FD 25
SETPC 5 PD FD 20 LT 45 FD 10 BK 10 RT 45 FD 10 BK 10 RT 45 FD
10 BK 10
PU HOME FD 15 LT 90 FD 25 SETPC 5
FD 20 RT 45 FD 10 BK 10 LT 45 FD 10 BK 10 LT 45 FD 10 BK 10
BROOM
END

TO COU :S
HT
REPEAT 360 [FD :S BK :S RT 1]
END

TO COLL
COL 30 ST PU HOME FD 40 PD COL 25 ST PU HOME FD 75 PD COL
15
END

TO ARC :L
RT 180
REPEAT 18 [FD:L LT 10]
END

TO EYE :S
SETPC 0
COLL EYES 2
PU LT 90 FD 10 RT 90
PD SETPC 0
REPEAT 360 [FD :S BK :S RT 1]
END

TO SCARF :S
HT SETPC 3
REPEAT 17 [FD :S RT 90 FD 1 RT 90 FD :S LT 90 FD 1 LT 90]
END

TO SCARF2
PU HOME FD 32 RT 90 FD 15 RT 45 PD ARC 5
PU HOME FD 32 RT 90 FD 15 RT 45 ARC 5
END

TO FLAKES
SETPC 1
                     DOT [50 120]         DOT [-3 47]
DOT [34 87]          DOT [-99 99]         DOT [-9 40]
DOT [-72 -57]        DOT [76 68]          DOT [-22 1]
DOT [-36 67]         DOT [35 -69]         DOT [84 -9]
DOT [36 86]          DOT [45 87]          DOT [-90 0]
DOT [37 -58]         DOT [-79 -67]        DOT [-6 6]
DOT [-29 -10]        DOT [87 62]          DOT [56 4]
DOT [28 10]          DOT [35 46]          DOT [-5 5]
DOT [-24 -77]        DOT [ 67 -33]        DOT [-120 80]
DOT [98 75]          DOT [56 10]          DOT [-124 90]
DOT [-24 66]         DOT [56 -23]         DOT [-135 56]
DOT [0 0]            DOT [67 -24]         DOT [-123 100]
DOT [0 56]           DOT [-35 64]         DOT [-142 69]
DOT [-55 0]          DOT [-15 6]          DOT [-155 190]
DOT [46 -69]         DOT [-2 34]          DOT [-111 89]
DOT [-77 32]         DOT [56 47]          DOT [-90 10]
                                          DOT [-123 97]
                                          END

TO HAT
PU HOME FD 65 LT 90 PD FD 25 BK 50 FD 15 RT 90 FD 20 LT 90
FD  20 LT 90 FD 20 BK 20 LT 90
REPEAT 10 [FD 20 RT 90 FD 1 LT 90 BK 20 RT 90 FD 1 LT 90]
END

TO BROOM
PU HOME BK 55 RT 90 FD 45 LT 90 PD SETPC 4 FD 65
LT 55 FD 25
REPEAT 8 [BK 25 RT 15 FD 25]
END
```

There was some concern among teachers that if they allowed their students to use the Koala Pad then they would not wish to return to Logo. This may be a legitimate concern if the teachers or students are not clear as to the objectives to be achieved while engaged in a particular activity. If the purpose is to explore and compare the process of creating a particular picture or design using different media, then both Logo and the Koala Pad can contribute to a greater understanding of the capabilities of different software and computers. If the focus is on analysis and problem-solving skills within a programming and mathematical context, using Logo to create a picture may also serve as an important medium. If, however, the final product is the important objective, then there is an advantage in using the fastest medium that will give the appropriate result. If the product is to be used within another primary activity, such as writing interactive stories with graphic displays interspersed throughout the text, then the Koala Pad medium may also be a desirable alternative. If artistic design is of primary importance, then both the process and the product can become important considerations since the medium very often shapes the nature and form of the finished product.

One of the main advantages of using the computer as an art medium is that it allowed students who have not mastered the fine motor control to create shapes and designs that "look good". As one Grade 1 student commented:

> I like the Koala Pad because you can draw things without doing all the typing, you just use your finger. You can get much better pictures too. (Feb. 2/84)

"Looking good" was extremely important to the young students. Although they were not discouraged from drawing by hand, they did appreciate being able to produce artwork that expressed their ideas but went beyond their present skills of manipulating pencils or a paintbrush. The contrast is evident in the drawing of the snowman done by a Grade 1 student with the Koala Pad and the drawing she made by hand in which she illustrated having made a snowman on the Koala Pad (Figure 13.4).

Many of the early explorations by students at all grade levels were in the form of writing their names, drawing simple designs with lines, and creating compositions with colours. As students gained greater control over their medium, many pictures began to reflect a well developed sense for detail and composition. A cross-section of drawings made on the Koala Pad by Grade 1, 3, and Grade 5 students are presented in Figures 13.1, 13.5, and 13.6. Colour, which could not be reproduced on the printer, was an important component of these activities for the students. The examples of pictures presented in this section were done for the sake of artistic exploration. Other pictures that made use of the Koala Pad, became an integral part of interactive stories which students designed and wrote. (Two such examples are presented in Figures 16.5 and 16.6. in Chapter 16.)

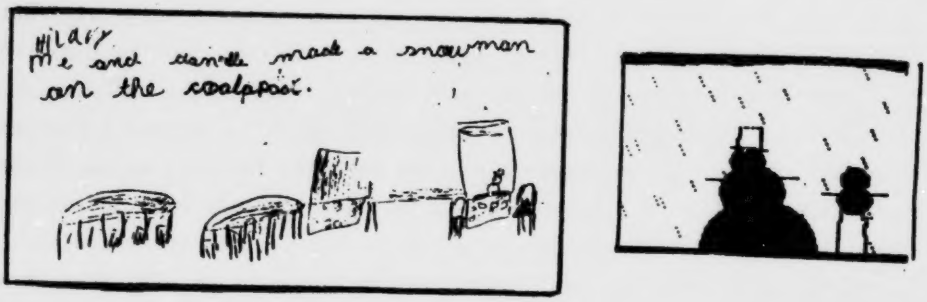
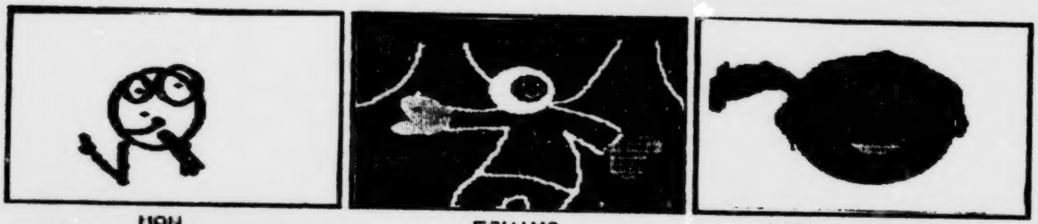
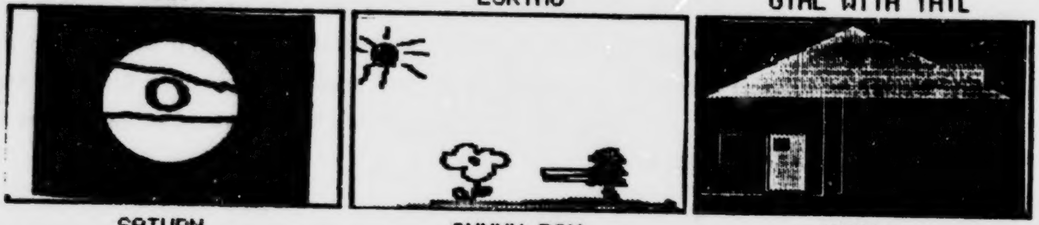

Hilary
Me and danielle made a snowman on the coalpad.

Figure 13.4
A Comparison of Two Pictures Produced by A Grade 1 Student: One by Hand and the Other on the Koala Pad

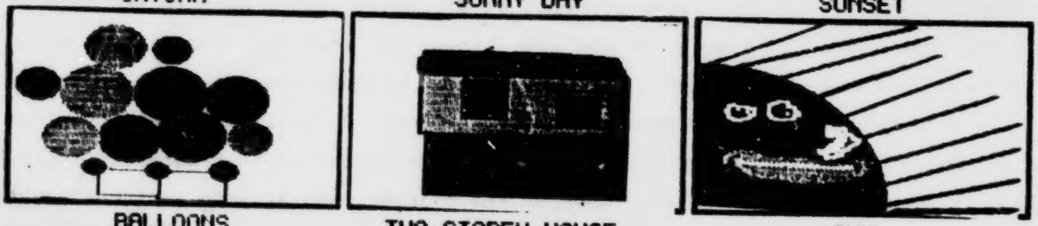
Figure 13.5
Examples of Pictures Drawn by Grade 3 Students Using the Koala Pad



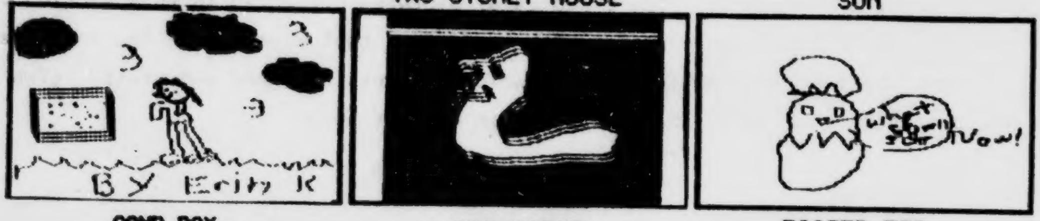
MAN ESKIMO GIRL WITH TAIL



SATURN SUNNY DAY SUNSET



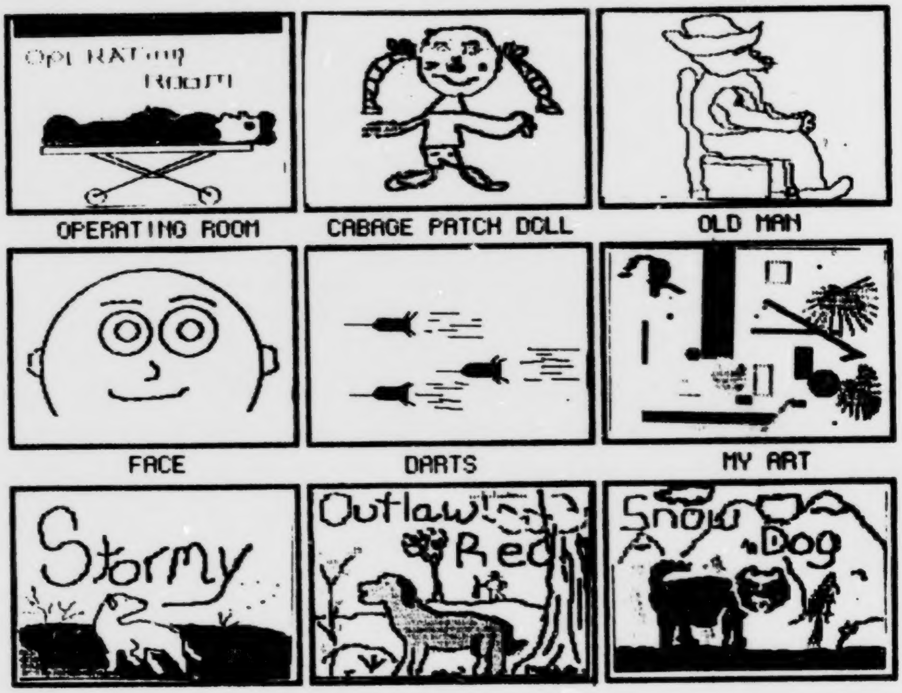
BALLOONS TWO STOREY HOUSE SUN


BY Erin K
Wow!

SAND BOX SEA HORSE EASTER EGG

Figure 13.6

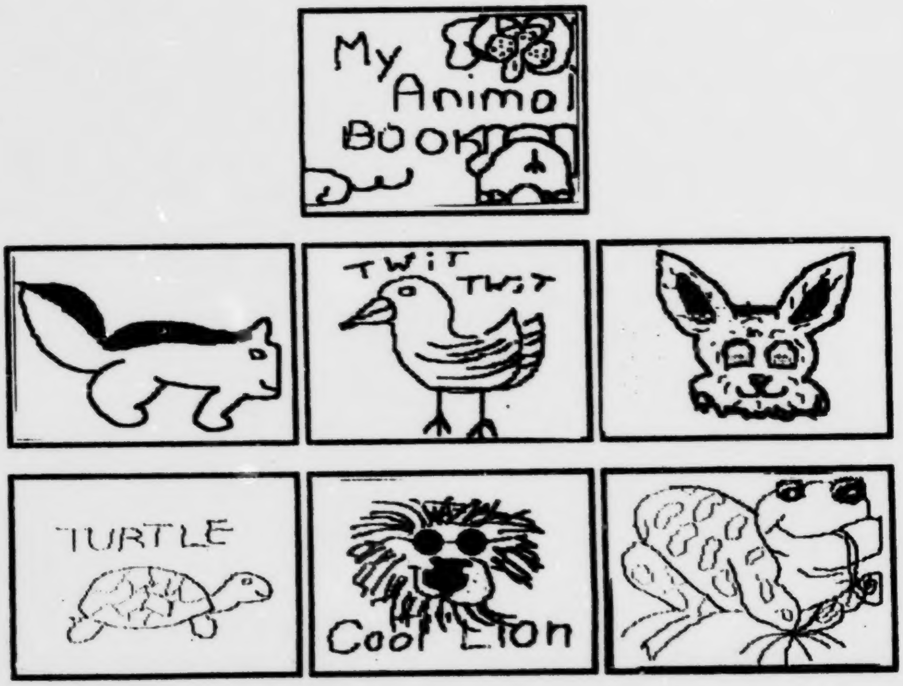
Examples of Pictures Drawn by Grade 5 Students Using the Koala Pad


OPERATING ROOM
Stormy
Outlaw Red
Snow Dog

OPERATING ROOM CABAGE PATCH DOLL OLD MAN

FACE DARTS MY ART

VARIATIONS ON A THEME: TITLE PAGES FOR BOOK REVIEWS


My Animal Book
TWIT
TWIT
TURTLE
Cool Lion

DESIGNING A PICTURE BOOK

The introduction of the Koala Pad in the Grade 3 class caused some distraction that caught the teacher rather unprepared. Although the class had two computers, only one was connected to a Koala Pad. Students were so curious and eager to use this new device that they temporarily lost interest in exploring with Logo. The teacher reported the following:

> What happened was the Koala pad!. Nothing was done in Logo or Bank Street Writer while the pad was in use. Even though the children had forty minutes without the Koala they did not use their time wisely. They wasted a great deal of time. Things certainly went backwards. No learning took place at all. ... Even suggesting different things to do did not help. They waited until they were back at the pad again. I have removed the pad and given as a project for them to work on a design which they can colour. They seemed to be keen on the idea. Maybe that is what they needed another set of ideas. (May 2/84)

This state of imbalance might have rectified itself in time since a student who had just expressed great delight in using the Koala Pad, when asked by one of the researchers whether she would prefer to use the Koala Pad all the time or Logo all the time, indicated that she would choose Logo "because you have to think harder".

14. MUSIC

Originally, the study of computer-based music activities was to have been an important part of this research project. However, none of the software that was "on the horizon" when the study began, became commercially available in time to carry out the anticipated in-depth study. Users of Terrapin Logo had a simple version of Logo Music which came with the Logo language utility disk and which needed no additional hardware. Sites where LCSI Logo was used did not have access to a music utility. The necessary hardware and software "Musicland" (a program developed at the University of Toronto by Martin Lamb and his colleagues as part of Ontario's Ministry of Education software development program) did not become available until very late in the study, which made it impossible to incorporate it into a "normal" classroom setting. The findings on Musicland which follow are therefore based on a group of eight Grade 3 students working outside the regular classroom with a private music consultant for approximately one week.

One immediate concern, even with limited use of the Logo music utility, was the potential interference from sounds coming from the computer with other activities in the class. The need for two sets of earphones per computer (because students most often worked in pairs) was considered necessary for any extensive use of music. Earphones were not made available during the course of this study, which may have influenced the extent to which musical activities were encouraged by the teachers.

LOGO MUSIC

This music program was briefly introduced to students by teachers at four sites. Because of the limited use of Logo music and the fact that very few students saved their explorations with music, the findings in this section are not based on representative samples drawn from a large pool of data, as was possible with turtle geometry and word processing, but instead are based on the few examples that were either collected from disks or observed during classroom visits. The classes that were exposed to Logo music were: Grade 1, Grade 3, a learning disability class, and an emotional adjustment class. (These teachers became excited about the possible use of Logo music after they attended a workshop by Professor Jean Bamberger of the Massachusetts Institute of Technology, sponsored by the the Faculty of Education at Queen's University).

The Grade 1 and Grade 3 teachers introduced their students to Logo music through a class lesson and through the use of laminated cards that were placed by the computer, giving the programming instructions, such as PLAY [   ][   ]. The numbers to be entered in the first set of brackets corresponded to the pitch of notes and those in the second set of brackets to the duration of notes. The Grade 1 students were given the numeric values for three notes: 5+ for 'mi', 8+ for 'so' and 10+ for 'la', and older students were free to choose from a wider range of notes. The students were then encouraged to make little tunes. One tune, composed by two Grade 1 students, was:

```
PLAY [5+ 8+ 8+ 10+] [80 40 60 80].
```

In the Grade 3 class, a few students became quite interested in experimenting with music. One pair enjoyed changing the rhythm. Another student, who sang in a choir, wrote the following four tunes:

```
TO TUNE1
PLAY [7+ 2+ 9+ 13+ 5+] [160 80 40 20 160]
END

TO TUNE2
PLAY [1+ 3+ 5+ 6+ 8+ 10+ 12+ 13+] [80 80 80
80 80 80 80 80]
END

TO TUNE3
PLAY [10+ 12+ 11+ 9+ 6+] [40 160 80 20 40]
END

TO TUNE
PLAY [1+ 3+ 5+ 6+ 10+ 12+ 13+ 13+ 12+ 10+ 8+
6+ 5+ 3+ 1+] [20 40 20 40 20 40 20 40 20 40
20 40 20 40 20]
END
```

He played these tunes in different orders until he found the arrangement that he liked. After he was shown how to combine his tunes into a procedure, he combined his tune into a song called VALENTINE:

```
TO VALENTINE
TUNE1 TUNE2 TUNE3 TUNE
END
```

Two other Grade 3 students explored with the following set of tunes:

```
TO TUNE
PLAY [13+ 12+ 10+ 8+ 6+ 3+ 1+] [40 40 40 40
40 40 40]
END

TO TUNE1
PLAY [13+ 3+ 1+ 5+ 10+ 12+ 8+] [40 40 40 40
40 40 40]
END

TO TUNE2
PLAY [13+ 3+ 5+ 10+ 12+ 8+] [20 20 40 40 40
40]
END

TO TUNE3
PLAY [12+ 6+ 5+ 10+ 3+ 13+ 1+] [40 40 40 40
40 40 40]
END

TO TUNE4
PLAY [5+ 8+ 10+ 6+ 3+ 1+ 13+] [40 40 40 40
40 40 40]
END

TO TUNE5
PLAY [1+ 6+ 10+ 3+ 5+ 8+ 1+] [160 160 160 160
160 160 160]
END

TO TUNE6
TUNE
TUNE1
TUNE2
TUNE3
TUNE4
TUNE5
END
```

One pair of Grade 3 students decided to combine music with graphics and text. They retrieved a picture (which they had made several months before) from their disk and created a "MUSICAL PICTURE" (Figure 14.1). They had the following to say about their picture:

> We did this picture a while ago when it was snowing. We decided to put some music and a question with it. It took hours of work because we kept on getting muddled up but we finally got finished. This is how it turned out. (June 10/84)

A boy in the learning disability class attempted to create the opening bars of Beethoven's Fifth Symphony in Logo music which he called OPERA. He experimented with the notes, then played it back, assessed the effect by ear, and continued to make adjustments in the program until he had the tune to his satisfaction. He also composed a song CLOSE.ENCOUNTER.OF.THE.THIRD.KIND. He thoroughly enjoyed composing and playing his tunes and expressed pleasure at being a composer. His programs were:

```
TO OPERA
PLAY [8 8 8 5] [12 12 12 190]
PLAY [8 8 8 3] [12 12 12 200]
PLAY [8 8 8 2 2 2 8 8 8 2] [12 12 12 12
12 15 12 12 15 190]
PLAY [8 8 8 2 2 2 8 8 8 2] [12 12 12 12
12 15 12 12 15 190]
PLAY [8 3 8 3 8 3 8 3] [12 12 12 12 12 12
12 12]
PLAY [8 8 8 10 8 8 8 10 4 4 4 5] [40 40 40
60 40 40 40 60 6 6 6 100] END

TO CLOSE.ENCOUNTER.OF.THE.THIRD.KIND
PLAY [1- 5 3 1 1-] [30 35 40 90 100]
END
```

Another student from that class explored with the following tune:

```
TO T.M.
PLAY [1  2  3  4  5  6  7  8  9  10  11  12  13  14  15
16  17  18  19  20  19  18  17  16  15  14  13  12  11
10  9  8  7  6  5  4  3  2  1][5  10  15  20  25  30  35
40  45  50  55  60  65  70  75  80  85  90  95  100  95
90  85  80  75  70  65  60  55  50  45  40  35  30  25
20  15  10  5]
END
```

The Grade 1 teacher extended the music experience and integrated it into a classroom activity by encouraging the whole class to write a Valentine poem which was to be set to music using the three notes: 'mi', 'so', and 'la'. Individual members of the class gave suggestions first for the words of the poem and then for the notes for the song. A discussion followed as to why a certain word or note should or should not be included. The song was first written on paper with a conventional staff and then programmed into the computer as a Logo procedure. The Valentine song in conventional and Logo Music notation is presented in Figure 14.2. During one of the regular class visits, one of the researchers observed two girls happily singing the Valentine song as they listened to it being played on the computer. While doing so, one of the girls had a copy of the song (in conventional notation) in front of her, and she very carefully followed each note that she heard on the computer with her finger on the sheet of paper. The two girls played the song over and over again which was easily done by pushing CTRL P and hitting the RETURN key. Another boy, who was somewhat lost in turtle geometry, was delighted with the song. He happily played and beautifully sang the song over and over again. When students had their regular talent show, one of the students sang the Valentine song to the whole class. The students exhibited genuine pleasure and pride in their song.

The teacher from the emotional adjustment class also set, as one of his objectives, the creation of a class song. However, he approached it by encouraging each student to focus on rhythm and to compose one four-beat bar, using only the notes 'mi' and 'so'. A poster with conventional staffing and note notations was placed on the wall next to the computer. When the boys finished their tunes, the computer version was transposed into conventional notation and posted on the wall. One version of the class song, in Logo notation, was:

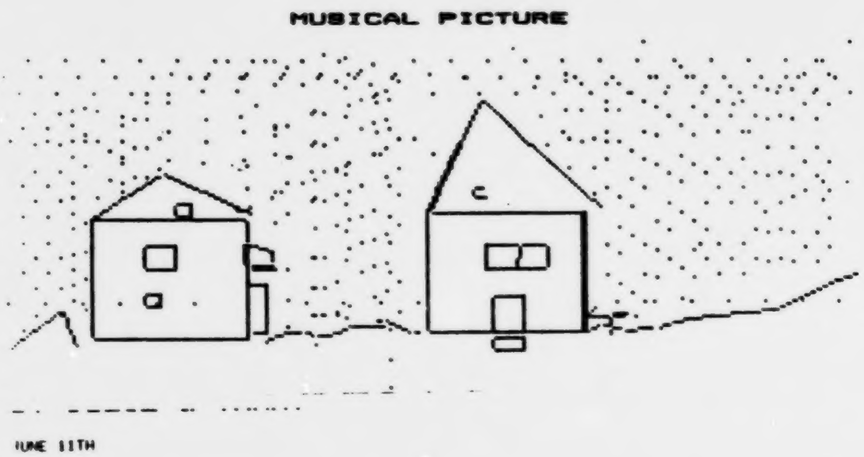
```
TO CLASS.SONG
PLAY [10+ 10+ 10+] [40 40 80]
PLAY [10+ 10+ 10+] [40 40 80]
PLAY  [10+  13+  6+  8+  10+] [40  40  50  20  90]
PLAY [11+ 11+ 11+] [40 40 50]
PLAY [11+ 11+ 10+] [20 40 40]
PLAY [10+ 8+ 8+] [40 40 40]
PLAY [10+ 8+ 13+] [40 80 80]
END
```

This became the basis for a more detailed discussion of musical notation, composition, and rhythm.

A girl in one of the Grade 8 classes became extremely bored with doing nothing but graphics for twelve weeks. During a class visit one of the researchers showed her how to use the music utility program and gave her the manual. She was delighted with this new activity and set out to explore its dimensions. When other students heard the sound, they became curious and expressed interest in working with music as well. Unfortunately, no explorations in music were saved by students in this class.

Figure 14.1

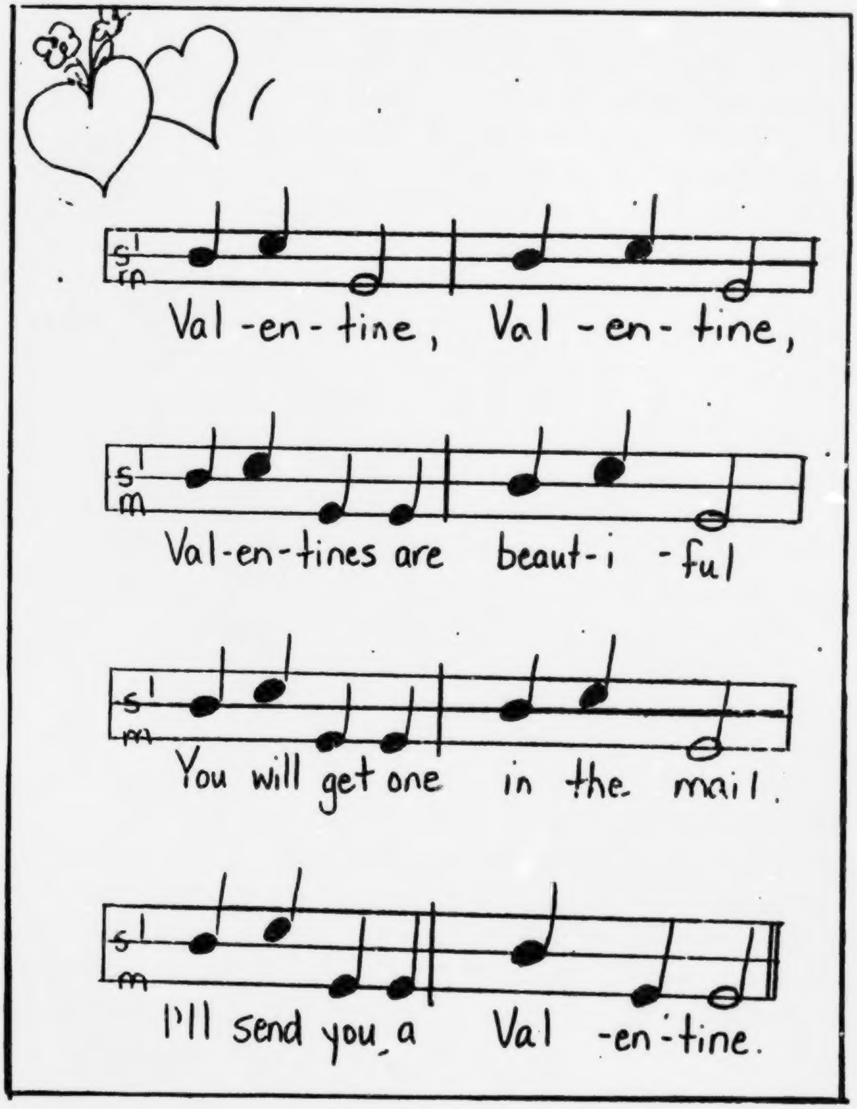
'Musical Picture' Created by a Grade 3 Student Which Combines Turtle Geometry, Interactive Text, and Logo Music



```
TO MU
PLAY [20+ 22+ 24+ 20+ 22+ 24+ 20+ 22+ 24+ 20+ 22+ 24+ 20+ 22+ 24+
20+ 22+ 24+ 20+ 22+ 24+ 20+ 22+ 24+ 20+ 22+ 24+ 20+] [10 30 10 30
10 30 10 30 10 30 10 30 10 30 10 30 10 30 10 30 10 30 10 30 10 30
10 30]
END

TO MPA
READPICT "SANTA'S8
MU
ASK
END

TO ASK
PR [DO YOU LIKE OUR PICTURE AND MUSIC TOGETHER?]
GET.ANSWER
IF :ANSWER = "YEs LISTEN
IF :ANSWER = "NO TRY
END

TO TRY
PR [WE TRIED OUR BEST.]
END

TO LISTEN
PR [THANK YOU!]
END
```

Figure 14.2

A Valentine Song in Conventional Notation Composed by a Grade 1 Class Which Was Then Converted to a Logo Music Procedure


s
m
Val-en-tine, Val-en-tine,
Val-en-tines are beaut-i-ful
You will get one in the mail.
I'll send you a Val-en-tine.

```
TO VAL
PLAY [8+ 10+ 5+ 8+ 10+ 5+ 8+ 10+ 5+ 5+ 8+ 10+ 5+ 8+ 10+ 5+ 5+ 8+
10+ 5+ 8+ 10+ 5+ 5+ 8+ 5+ 5+] [40 40 80 40 40 80 40 40 40 40 40 40
80 40 40 40 40 40 40 80 40 40 40 40 40 80]
END
```

MUSICLAND

Musicland is a series of computer games which encourage the active exploration of several musical dimensions through composition. The games are delivered on an APPLE II+ or IIe, with an additional Mountain Hardware board to produce the synthesized sounds through an amplifier/speaker system. Input is through a Koala Pad.

One game, Music Doodles, asks the user to draw melodic lines, and allows him or her to transform segments or figures, repeating them elsewhere in the composition. In Timbre Painting, the student is invited to orchestrate the composition, choosing any combination of five colours representing five different timbres. If the student wishes to change the sound of one of the instruments, he or she can do this by moving to another game, called Sound Factory. Here the student is given the waveform, fundamental and overtone structure of the instrument, all of which can be changed simply by manipulating the display using the Koala Pad. Finally, the student can assemble an entire composition by co-ordinating various Music Doodles together in the Music Boxes game.

In this study, Musicland was introduced to eight students from a Grade 3 classroom, who were selected by the classroom teacher. The teacher was asked to choose four boys and four girls, who represented the various levels of ability and interest in the class. None of the students selected had worked together as partners in their other computer activities, and none of them had any music training outside the public school music program.

The students used Musicland in a small room in the library. They usually worked in pairs, with the exception of the first session, where the system was introduced to the whole group. One student was shown how to operate the Koala Pad, and how each of the games could be played. This took about forty-five minutes. Three days later the same student was asked to explain Musicland to his partner. Then the two of them taught the next pair, the second pair taught the third pair, and finally, the third pair informed the fourth. The students were supervised during that time by a music teacher with knowledge about Musicland. The students were then given time to work unsupervised with Musicland, for a total of eighty minutes per pair (two 40-minute sessions). Each pair then had an opportunity to spend another forty minutes sharing their discoveries with the music teacher who introduced the system.

Findings

Although 20-minute, 40-minute, and 60-minute sessions were tried, it was found that the 40-minute period seemed to work best since students tended to spend approximately ten minutes on each game. In forty minutes, four games could be played. Often the students took turns using the Koala Pad, alternating so that each student used the Koala Pad for twenty minutes. While one student was entering music or changing the quality of the notes, the other was actively engaged in making suggestions.

The use of the Koala Pad as the input device, along with screen displays of easily understood commands, made it possible for all of the students to grasp the mechanics of Musicland and, in turn, explain them to others with little adult intervention being necessary. The students created doodles on the basis of visual criteria, since the Koala Pad lent itself well to "drawing music". The students were curious to find out what their names or simple shapes sounded like. Some students reported that the "straight line shapes were the most interesting". It seemed that the straight lines were popular because the students could readily predict the sounds that such drawings would produce (i.e., ascending or descending scale passages in the case of oblique lines, long single notes for horizontal lines, and single loud notes for horizontal lines). None of the students were interested in attempting to work with small musical units (such as a three note motif). This was partly due to the difficulty of single note input but also due to the fact that smaller musical units did not create such an "impressive" sound as the doodles students created. In order to focus on a study of motif, more directed instruction would have been required.

Almost all of the students used Music Doodles to introduce the system to a first time user. They also were most likely to use Music Doodles to show what they had done on their own, even though all of the games were explored by each student. This game gave the students the most control over the music created. Also, the correspondence between the visual display and the music heard for Music Doodles and Timbre Painting appeared to be intuitively understood by most of the students. By contrast, in Sound Factory the students did not seem to understand how their changes to the visual display affected the sound. While students understood how to create compositions with Music Boxes, this game was not often explored. A possible reason was that most of the doodles were without formal structure, and stringing together a series of unstructured or unrelated segments rarely led to interesting results. Usually a series of boxes of the students' doodles simply resulted in more of the same "Close Encounters" sound. Better use of Music Boxes might have been made if students had been asked to put a series of boxes together to form a tune, based on boxes created by the teacher. In this way, students might have learned how boxes or musical motifs are put together to build a structured melody.

Students were quickly able to grasp the parameters of the notation and its layout on the keyboard. In Musicland, the length of a note or its duration is directly related to the length of the bar corresponding to the note. Thus, note "A", sounding for three times the length of "B" would be shown by a bar three times as long as the bar for "B". This direct correspondence was easy for students to learn, because of the simultaneous display of the visual representation with the sound. It should be noted, however, that the notation for duration is different to that of standard music notation. At some point, therefore, a transition would have to be made between the two forms of notation if the student were to read from standard notation.

The students were also able to learn about pitch placement on the staff. Here the Musicland notation is more closely in line with standard music notation, with the exception that no accidentals are shown. Instead, spatial distance is used. For example, while the unit in standard notation is the distance between a space and a line, or vice versa, in

Musicland, there is an additional unit between the space and the line, corresponding to the half step which is generally marked by an accidental (sharp or flat). At any rate, the relative placement (high at the top of the staff, low at the bottom of the staff) is preserved, and it was the relative placement which students were able to comprehend quickly. Not surprisingly, the students were not able to pinpoint the location of discrete pitches on the staff.

Although the students began by exploring the scope of the games with little thought to the music they were creating, their explorations became much more systematic after about half an hour with the system. They began with "wild" doodles, giving little or no thought to the final product. They soon switched to very simple doodles which allowed them to co-ordinate the visual display with the sounds. Then they frequently built more complex doodles by carefully placing their lines according to their findings from the simple doodles. The ideas for music doodles were usually created on the spot, although one pair of students often came to the computer with an idea they had developed previously. However, the students were not systematic in exploring the effects of varying the overtone structure. For instance, one group made a series of steps from the overtones. The students' judgments of the new timbres created in the Sound Factory were limited to a low level assessment of whether they found the new timbre pleasing or not, for example, "Oh, that one's kinda neat," or "I liked the other one better".

Conclusions

While Musicland allowed the students to relate effectively the various global musical dimensions, it is not a system well-suited for teaching the finer points of musical structure since single note input is not a developed feature. However, this could be overcome by integrating the use of Musicland with a music teaching program which addresses such issues as transformation of motif, counterpoint, harmony, mode/key, and so on. Musicland makes it possible for students to engage in sophisticated musical concepts - such as transformation and melodic line - which are usually denied to children in primary school music programs. From the present study, it is clear that children are capable of understanding more than they are currently challenged with, and the onus should now be on the teachers to give children more challenging musical experiences. Musicland also made it possible for children to make predictions about sounds based on the visual notation. This is one of the most important benefits of using Musicland. The kinds of predictions that the students in this study were able to make, however, were often on the basis of leading questions on the part of the teacher. For example, the students were asked how to make a single loud sound or many low sounds. These sorts of questions should be used in conjunction with Musicland, and are available in the form of activity cards for student and teacher. On the basis of the observations made in this brief study, it would seem that Musicland could serve as incentive for children to learn a musical instrument, insofar as the system makes it possible for children to understand some of the music fundamentals almost intuitively. Musicland would also serve as a useful tool for exploring musical ideas once a child achieved some success at playing an instrument. It is a sufficiently flexible tool to accommodate the more sophisticated ideas which would likely develop with performance. Musicland also appears to be a fine way to "demystify" music and to integrate the musical dimensions, giving primary children a deeper musical experience. However, unless it is supplemented by teaching (with or without computers) that emphasizes both the theory and performance aspects of music, the use of Musicland as a classroom or private teaching tool will be limited.

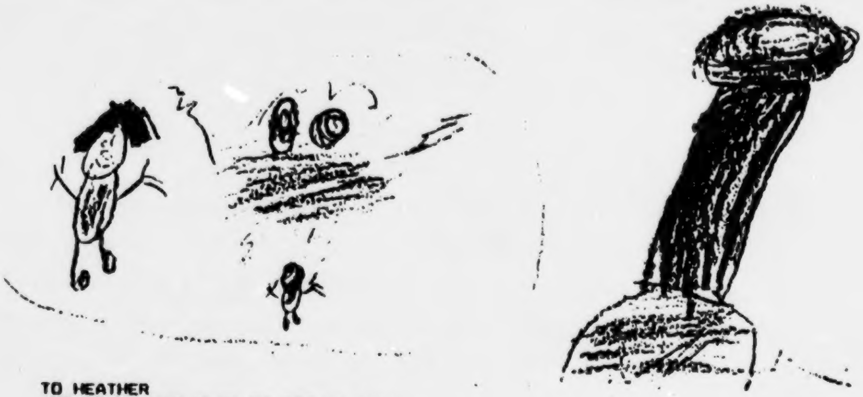
15. WORD PROCESSING

The primary software for word processing used in this study was the Bank Street Writer (BSW). However, the Logo editor (which is the standard editor of the Logo language used for defining procedures) and the Logo Text Editor from the Terrapin utility disk, also served as simple forms of word processors. It was found that the BSW with its extensive menu selection was too difficult to be used below the Grade 3 level, and even some junior and intermediate level students experienced some confusion with it at the outset. One of the Grade 1 teachers found the Logo editor a suitable medium for her students who were already familiar with some of the language's editing features. Even though her students were reluctant to use the Logo editor for defining graphics procedures, the initiating command (such as TO SHERRY, TO HEATHER, TO DIARY), and END for entering and exiting the editor were natural commands for beginning and closing a letter. The Logo editor was also used in a Grade 3 class for a limited time. The editor made it possible to take advantage of the standard editing features of the Logo language, such as deleting or inserting letters or words, and inserting or deleting lines. By giving the command PO (Printout and the name of the procedure), the entire procedure could be "dumped" onto the printer. Typical examples of such students' work from Grade 1 and Grade 3 are given in Figure 15.1. A limiting feature of using the Logo editor for word processing was that a word at the end of a line was broken up rather than moved to the next line as a complete word. This was not a serious problem since students tended to view the 40-column screen as the limit to the length of a line and young students tended to write short lines quite naturally. Other "annoyances" included each "story" starting with TO and closing with END and the letters all being capitalized. It also was not possible to indent lines or to create double spacing merely by moving the cursor to the appropriate spot. The Grade 1 teacher found that her students had some difficulty reading the printouts. A procedure called PRINTIT (see Appendix D) was written for the class which gave double spacings between lines, enlarged the print, and eliminated TO and END in the printout. Samples of the printed output with PRINTIT are shown in Figure 15.2.

The Logo text editor that is available on the Terrapin utility disk (which also makes use of the standard editing features of the Logo language) still has only capital lettering and truncates words at the end of a line, but it does recognize horizontal and vertical spacing within the text. In this form, it gave some control over the physical layout of the final text and it eliminated the TO and END feature of the straight editor. It did, however, require the use of the utility disk and learning additional terminology such as SAVETEXT and PRINTTEXT. Potentially confusing was the fact that to define a text file CTRL G rather than CTRL C had to be used, and if one wanted to get back to a file the word EDIT was mandatory; the common TO would wipe out the entire text in the workspace. The teacher of a Grade 7/8

Figure 15.1

Examples of Students' Writing Using the Logo Editor and the PO Primitive for Printing



```
TO HEATHER
 MR JELLY WAS GLAD TO SEE MR HAPPY .
 ON THE BOOT IT WAS SHINING OUT SIDE IT.
 WASINT RAINING THE TREES WRR GREEN OUTSIDE MR SMALL IS RED HE IS SMALL HIS/.
 TOOTH IS BLACK AND BLUE END
END
```

```
TO ROB
 1234567890: - QWERTYUIOP
 ASDFGHJKL ; ZXCVBNM,./1234567890:QWERTYUIOP
 ASDFGHJKL ; ZXCVBNM,./1234567890:QWEERTYUIOP
 ASDFGHJKL ; ZXCVBNM,./
END
```

```
TO CK
 1098653210
 FD 100
 RT
 BK
 LT
 HOME
 END
END
```

```
TO CARROT
 I LIKE MY CARROT.
 I PLAY WITH MY CARROT.
 MY CARROT IS BIG.
 MY CARROT SLEEPS ON THE BOTOM OF MY
 BED.
END
```

GRADE 1

```
TO DIARY
 TODAY I PLAYED WITH JEANETTE WE HAD
 LOTS OF FUN.WE PLAYED WITH CHRIS
 AND JOHNNY.JOHNNY AND CHRIS CHASED
 US.BUT THEY NEVER CAUGHT US BECAUSE W
 E
 WERE TOO FAST.BUT THEY CAUGHT US ONCE
 BECAUSE WE DID NOT RUN FROM THEM.
 THEY DID NOT RUN FROM US.
END
```

```
TO POEM
 ONE LITTLE FOX
 ONE DAY A LITTLE FOX WENT OUT TO PLAY.
 HE SAW A RABBIT IT WAS FLUFFY WHITE.
 THE RABBIT HAD A TAIL LIKE A COTTON BALL.HE WAS A VERY CUTE RABBIT.
END
```

```
TO DIARY
 TODAY MY MOTHER AND I ARE GOING TO THE ANIMAL HOSBTLE TO PICK UP OUR KITTEN. HE GOT HIS CLAWS
UT ON MONDAY.AFTER HE GOT HIS CLAWS OUT HE SLEPT.WHEN HE WOKE UP THE NURSE GAVE HIM SOME WARM M
LK.HE PROBABLY LIKED THAT.BECAUSE HE DOESN'T GET MILK AT HOME.I                    CAN'T WAIT UNTIL
 I GET HOME .BECAUS WE ARE GOING WHEN I GET HOME.
END
```

GRADE 3

Figure 15.2

Examples of Grade 1 Students' Writing Using the Logo Editor and the PRINTIT Procedure for Printing

WE ARU GOING TO THE BOOK
FAIR.

I WENT TO CANADAS' WONDERLAND ON
FRIDAY.WHEN I WENT ON THE BOUTS
MY DAD LOST HIS HAT AND THE MAN
FOWND MY DADS HAT.HE WAS HAPPY.
THE NEKST ROLRCOSTR IT WAS FUN.
BUT IT WENT UPSIDE DOWN.DO YOU
NOW WHAT?MY DAD SCREMED.

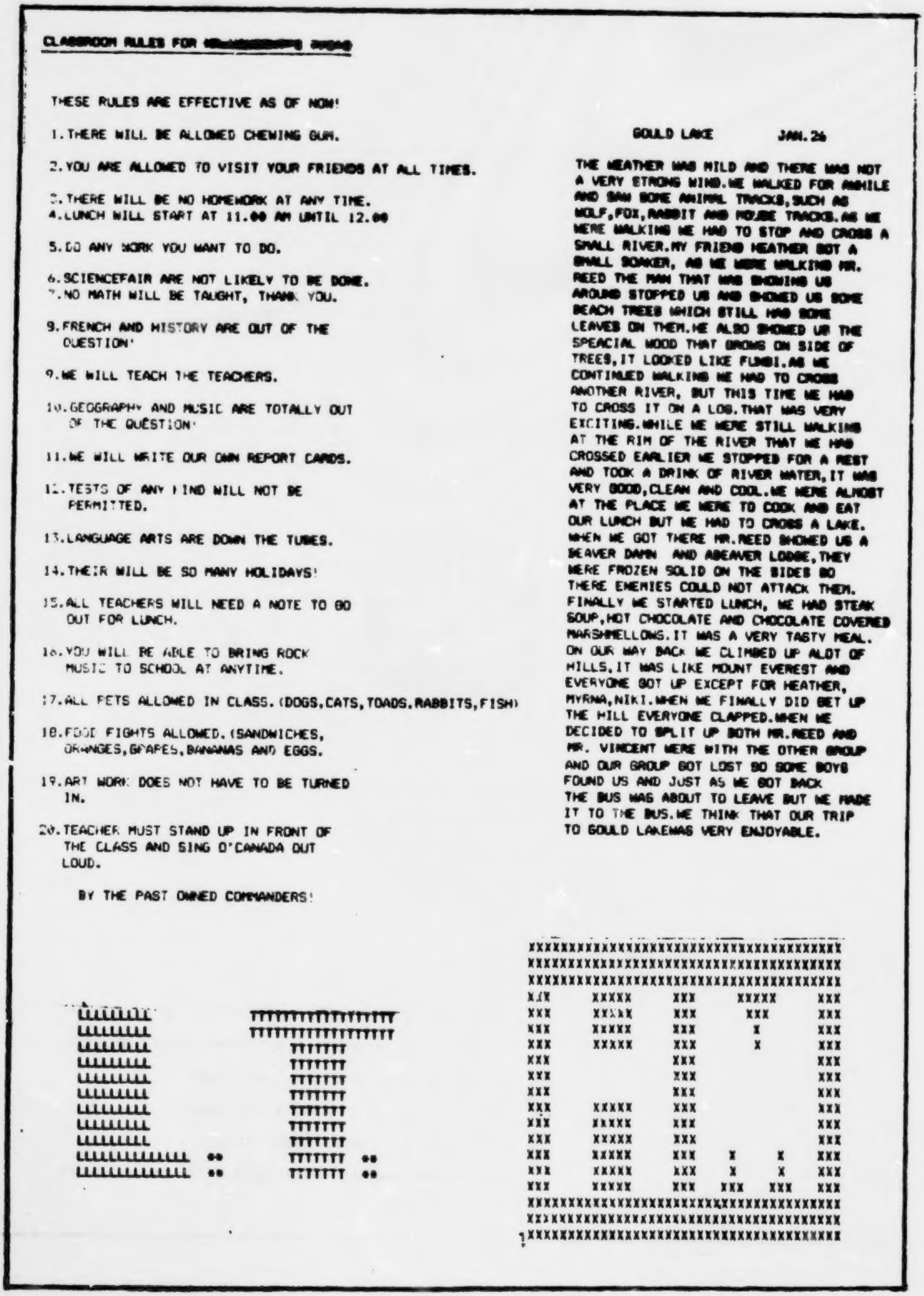
TODAY I GOT TO WROK ON THE COMPUTER
AND KEVIN WROKD WITH ME I.A,M GETING
NEW BEDS

BBBBBBBBBBBBBBBBBBBBBBBBBBBBBB
BBBBBBBB B B B B B B B B B B B
D D D D D D D D D D D D D D D
DD DD DD DD DD DD DD DD DD DD
BOX BOB BROWN BK BG
DANINELLE BEARS BIG DOWN
ET THE DOG

TODAY IS TUESDAY MAY 29 1984.
TODAY I BROT MY CABBIGE PACH
KID BLAKKIY TO SCHOOL.
MY GROP IS IN THE BOOK
MR SILLY ON THE FARM.
WE ARE MAKEING BOOKS OV LOGO
IT IS FUN.

Figure 15.3

Examples of Grade 7 and 8 Students' Writing Using the Logo Text Editor On the Terrapin Logo Utility Disk



CLASSROOM RULES FOR [redacted]

THESE RULES ARE EFFECTIVE AS OF NOW!

1.THERE WILL BE ALLOWED CHEWING GUM.

2.YOU ARE ALLOWED TO VISIT YOUR FRIENDS AT ALL TIMES.

3.THERE WILL BE NO HOMEWORK AT ANY TIME.
4.LUNCH WILL START AT 11.00 AM UNTIL 12.00

5.DO ANY WORK YOU WANT TO DO.

6.SCIENCEFAIR ARE NOT LIKELY TO BE DONE.
7.NO MATH WILL BE TAUGHT, THANK YOU.

9.FRENCH AND HISTORY ARE OUT OF THE QUESTION'

9.WE WILL TEACH THE TEACHERS.

10.GEOGRAPHY AND MUSIC ARE TOTALLY OUT OF THE QUESTION'

11.WE WILL WRITE OUR OWN REPORT CARDS.

12.TESTS OF ANY KIND WILL NOT BE PERMITTED.

13.LANGUAGE ARTS ARE DOWN THE TUBES.

14.THEIR WILL BE SO MANY HOLIDAYS!

15.ALL TEACHERS WILL NEED A NOTE TO GO OUT FOR LUNCH.

16.YOU WILL BE ABLE TO BRING ROCK MUSIC TO SCHOOL AT ANYTIME.

17.ALL PETS ALLOWED IN CLASS.(DOGS,CATS,TOADS.RABBITS,FISH)

18.FOOD FIGHTS ALLOWED.(SANDWICHES, ORANGES,GRAPES,BANANAS AND EGGS.

19.ART WORK DOES NOT HAVE TO BE TURNED IN.

20.TEACHER MUST STAND UP IN FRONT OF THE CLASS AND SING O'CANADA OUT LOUD.

BY THE PAST OWNED COMMANDERS!

GOULD LAKE JAN.26

THE WEATHER WAS MILD AND THERE WAS NOT A VERY STRONG WIND.WE WALKED FOR AWHILE AND SAW SOME ANIMAL TRACKS,SUCH AS WOLF,FOX,RABBIT AND MOUSE TRACKS.AS WE WERE WALKING WE HAD TO STOP AND CROSS A SMALL RIVER.MY FRIEND HEATHER GOT A SMALL SOAKER, AS WE WERE WALKING MR. REED THE MAN THAT WAS SHOWING US AROUND STOPPED US AND SHOWED US SOME BEACH TREES WHICH STILL HAD SOME LEAVES ON THEM.HE ALSO SHOWED US THE SPEACIAL WOOD THAT GROWS ON SIDE OF TREES,IT LOOKED LIKE FUNGI.AS WE CONTINUED WALKING WE HAD TO CROSS ANOTHER RIVER, BUT THIS TIME WE HAD TO CROSS IT ON A LOG.THAT WAS VERY EXCITING.WHILE WE WERE STILL WALKING AT THE RIM OF THE RIVER THAT WE HAD CROSSED EARLIER WE STOPPED FOR A REST AND TOOK A DRINK OF RIVER WATER,IT WAS VERY GOOD,CLEAN AND COOL.WE WERE ALMOST AT THE PLACE WE WERE TO COOK AND EAT OUR LUNCH BUT WE HAD TO CROSS A LAKE. WHEN WE GOT THERE MR.REED SHOWED US A BEAVER DAMN AND ABEAVER LODGE,THEY WERE FROZEN SOLID ON THE SIDES SO THERE ENEMIES COULD NOT ATTACK THEM. FINALLY WE STARTED LUNCH, WE HAD STEAK SOUP,HOT CHOCOLATE AND CHOCOLATE COVERED MARSHMELLOWS.IT WAS A VERY TASTY MEAL. ON OUR WAY BACK WE CLIMBED UP ALOT OF HILLS,IT WAS LIKE MOUNT EVEREST AND EVERYONE GOT UP EXCEPT FOR HEATHER, MYRNA,NIKI.WHEN WE FINALLY DID GET UP THE HILL EVERYONE CLAPPED.WHEN WE DECIDED TO SPLIT UP BOTH MR.REED AND MR. VINCENT WERE WITH THE OTHER GROUP AND OUR GROUP GOT LOST SO SOME BOYS FOUND US AND JUST AS WE GOT BACK THE BUS WAS ABOUT TO LEAVE BUT WE MADE IT TO THE BUS.WE THINK THAT OUR TRIP TO GOULD LAKEWAS VERY ENJOYABLE.

```
LLLLLLLLL             TTTTTTTTTTTTTTTTTTT
LLLLLLLLL             TTTTTTTTTTTTTTTTTTT
LLLLLLLLL                   TTTTTTT
LLLLLLLLL                   TTTTTTT
LLLLLLLLL                   TTTTTTT
LLLLLLLLL                   TTTTTTT
LLLLLLLLL                   TTTTTTT
LLLLLLLLL                   TTTTTTT
LLLLLLLLL                   TTTTTTT
LLLLLLLLLLLLLL   ••         TTTTTTT   ••
LLLLLLLLLLLLLL   ••         TTTTTTT   ••
```

```
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
XXX     XXXXX    XXX     XXXXX    XXX
XXX     XXXXX    XXX      XXX     XXX
XXX     XXXXX    XXX       X      XXX
XXX     XXXXX    XXX       X      XXX
XXX              XXX              XXX
XXX              XXX              XXX
XXX              XXX              XXX
XXX     XXXXX    XXX              XXX
XXX     XXXXX    XXX              XXX
XXX     XXXXX    XXX              XXX
XXX     XXXXX    XXX    X     X   XXX
XXX     XXXXX    XXX    X     X   XXX
XXX     XXXXX    XXX   XXX   XXX  XXX
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
```

class used this text editor before the BSW was available for developing some familiarity with a word processor. Examples of output that made use of this version of a word processor are given in Figure 15.3.

The subsequent findings discussed in this section are based on data gathered from sites 2 (Grade 1), 5 (Grade 3), 6 (Grades 5, 5/6), 8 (Grades 6/7, 7) and 9 (Grades 7/8, 8). Some use of word processing with the software Magic Writer was made in sites 7a (Grade 5), and 11a (Grade 8), but not enough data was generated from these two sites to make any comparison between it and the BSW. The classes that generated the most data with respect to word processing were Grade 3 (sites 5a, 5b), and Grades 5/6 (sites 6a;b,ab), where the BSW was used quite extensively. Additional data was obtained from a Grade 1 class (sites 2a, 2b) which used the Logo editor, and from Grades 6/7 (sites 8a;b,ab) and Grades 7/8 (sites 9a;b,ab), classes that used the BSW to a limited extent.

The impact of word processing depended very much on the relative degree to which the skills required to use the "technology" for writing had been mastered. A pencil or pen can be viewed as a simple technological device for writing. In order to master that technology a student has to have sufficiently well developed fine motor control for handling a pencil. Fine motor control affects the ability to control the pressure of impact and the ability to formulate letters and words. For example, when students were asked whether they found writing with a word processor easier, harder or the same, 10 out of 15 Grade 3 students who found the word processor easier, mentioned without any prompting that when they write with a pencil their hands hurt or got tired and they couldn't write quickly. Some young children can write quite "neatly", but only slowly and with considerable difficulty. For example, compare a Grade 3 student's casual writing of her name with the way it is written on a piece of paper which was handed to the research team.

P am e l a Pamela

Observers who have watched young children struggle with handwriting, especially if it is supposed to be "neat", will be familiar with the following sight: a tight grip on the pencil, sometimes contorted facial movements that change with the movement of the pencil, and frequently a head resting on the table. By contrast, most children at the computer keyboard sit erect, are relaxed and intent, and patient in hunting for the appropriate key on the keyboard. This concern over the mechanics of writing was reduced to 8 out of 21 at the Grade 5 level but an additional 6 mentioned that "you just have to type". By Grade 7 and 8,only 5 out of 10, and 2 out of 9 students respectively, who found the word processor easier, made reference to some difficulty with the mechanics of writing.

In addition to fine motor control, handwriting requires that students also possess a reasonable degree of eye-hand co-ordination so that they do not transpose letters, can write in straight lines, arrange their writing in an orderly manner on a page, and master the techniques of erasing and sharpening a pencil - a point worthy of mention by a number of Grade 3 and Grade 5 students. Examples of students' handwriting, collected from Grade 1 (Figure 15.4), Grade 3 (Figure 15.5), and Grade 8 (Figure 15.6) illustrate some of these features.

Figure 15.4

Examples of Students' Handwriting From Grade 1

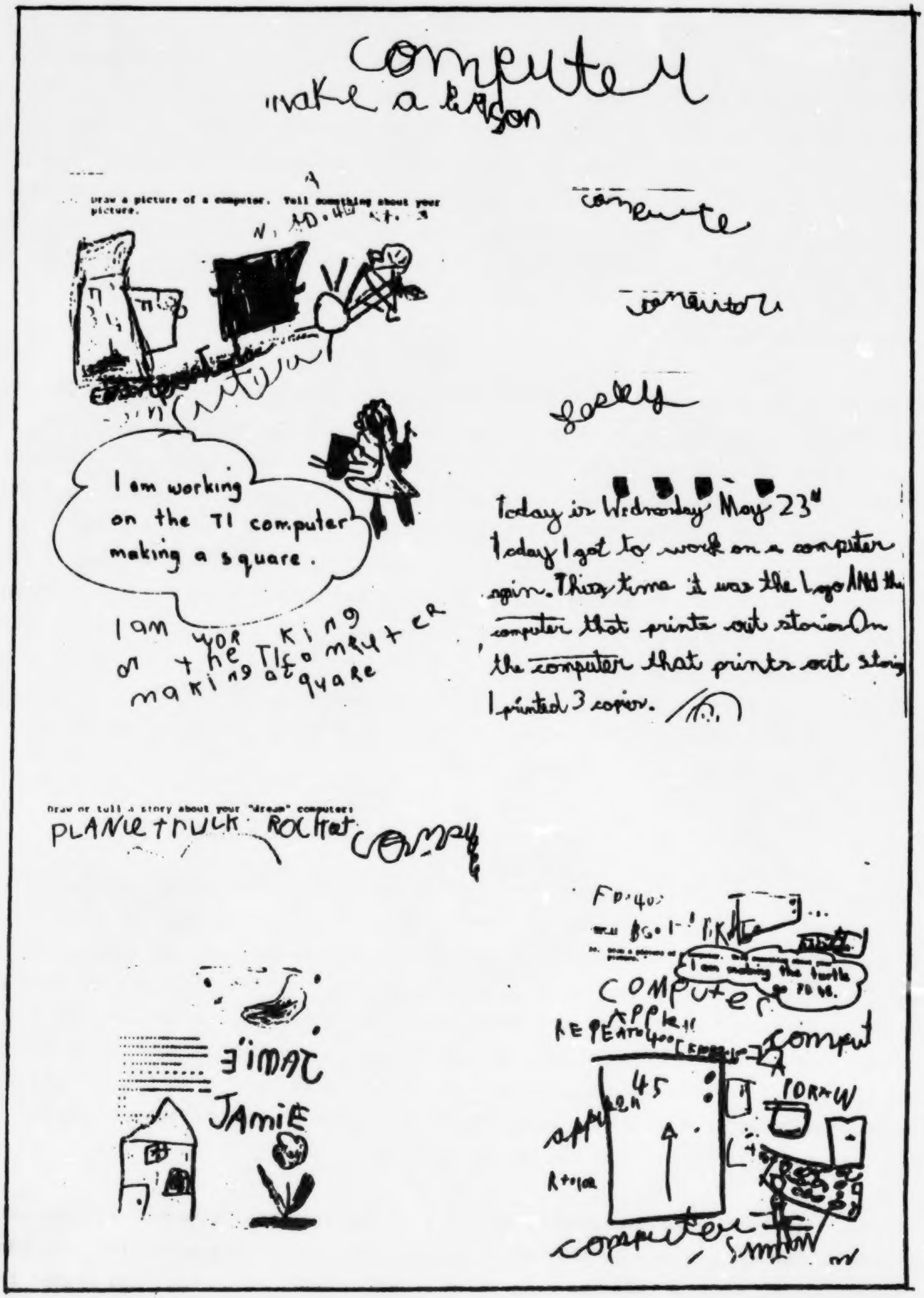
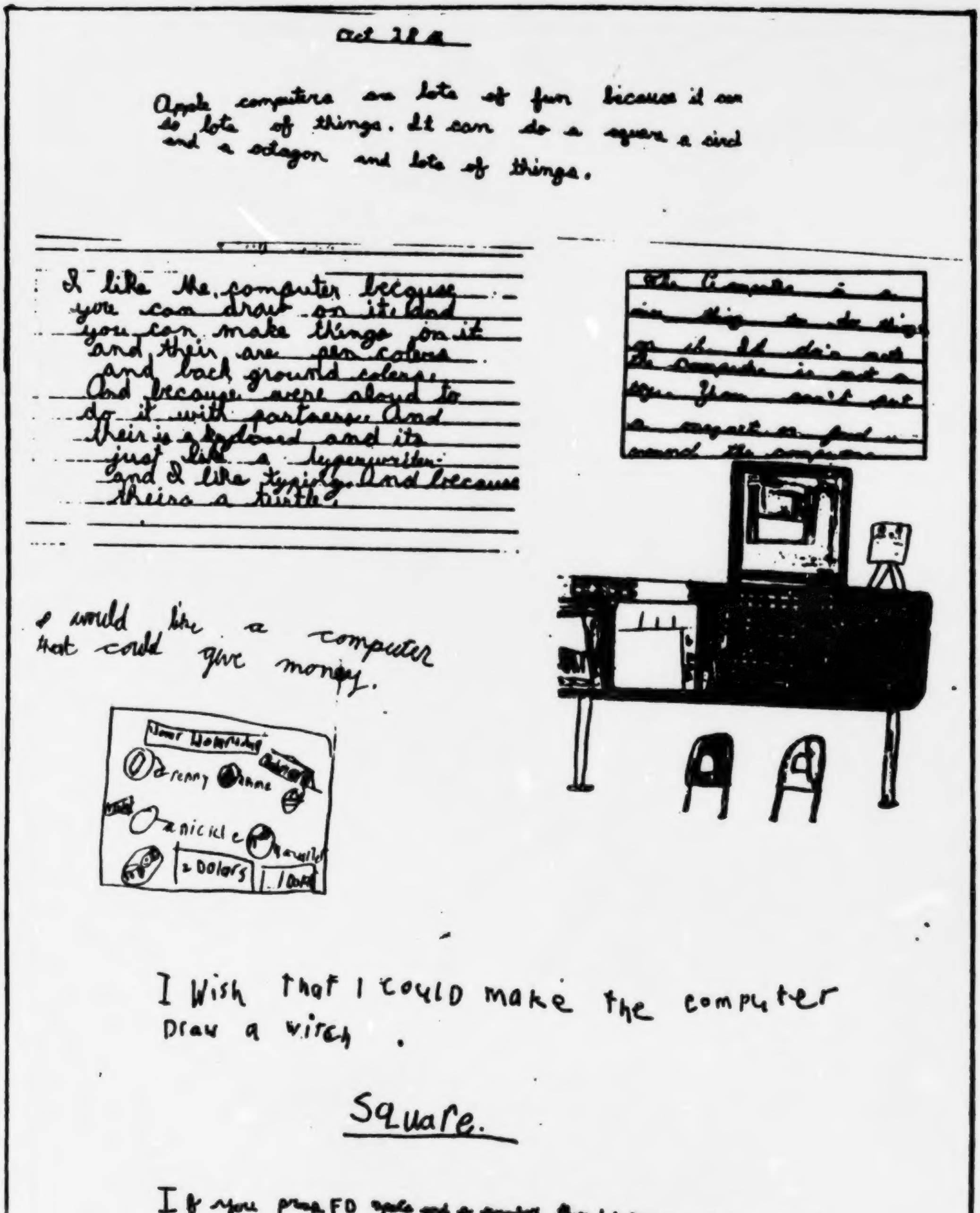

computer
make a lesson
Draw a picture of a computer. Tell something about your picture.
comeute
comeutor
I am working on the TI computer making a square.
I am working on the TI computer making a square
Today is Wednesday May 23
Today I got to work on a computer agin. This time it was the Logo AND the computer that prints out stories. On the computer that prints out story I printed 3 copies.
Draw or tell a story about your "dream" computer:
PLANE truck Rocket compu
JAMIE
I am making the turtle go 70 FD.
COMputer
REPEAT
comput
45
computer
Simon

Figure 15.5

Examples of Students' Handwriting From Grade 3



Act 11 a

Apple computers are lots of fun because it can
do lots of things. It can do a square a circl
and a octagon and lots of things.

I like the computer because
you can draw on it. And
you can make things on it
and their are pen colors
and back ground colors.
And because were aloud to
do it with partners. And
their is a keyboard and its
just like a typewriter.
and I like typing. And because
theirs a turtle.

The Computer is a
[illegible] thing to do things
on it. It do's not
the Computer is not a
toy. You can't put
a magnet or food
around the computer

I would like a computer
that could give money.

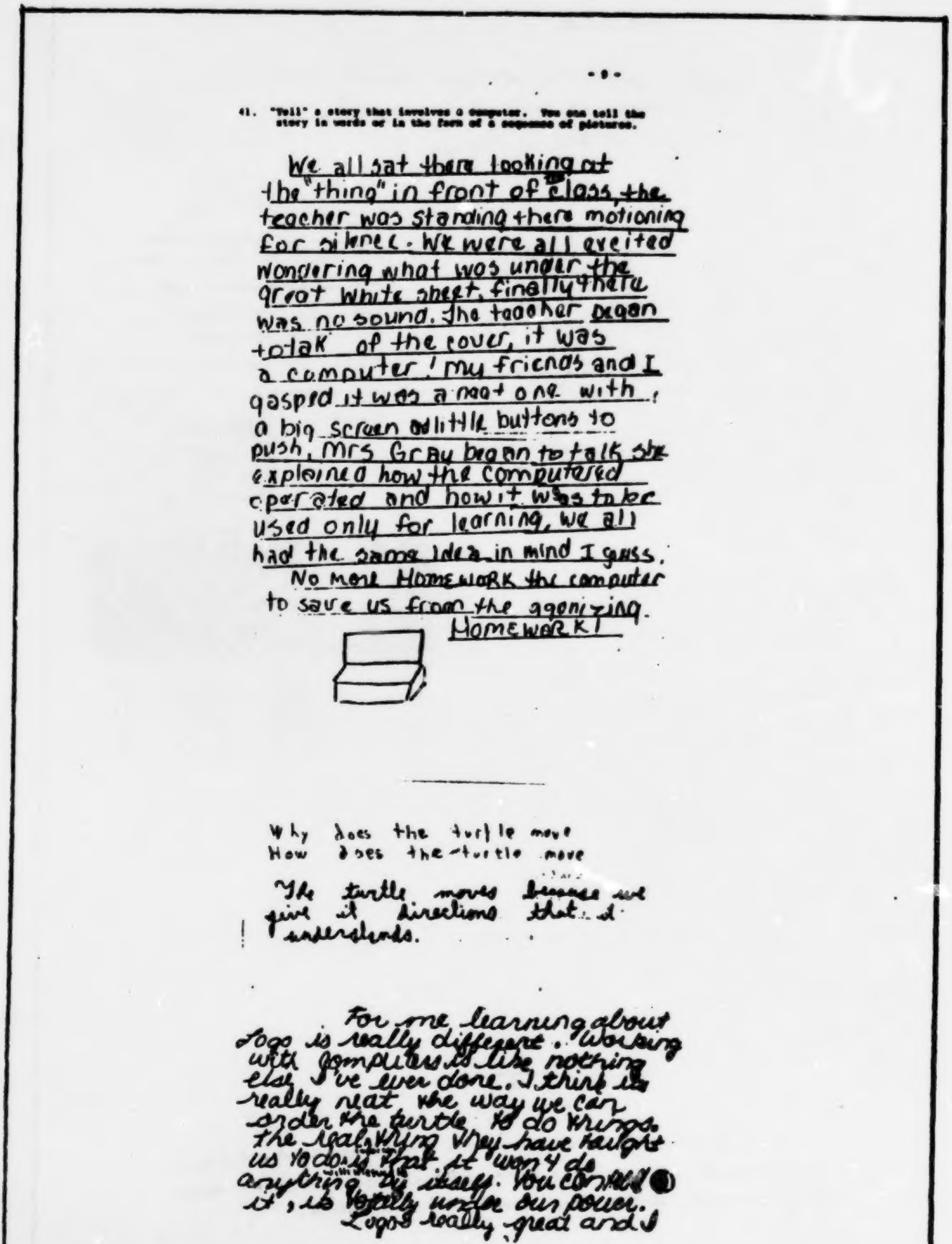
I wish that I could make the computer
Draw a witch .

Square.

If you press FD space and a number then Lt space 90 then FD space
and a number of 100 Lt 90 space FD space 100 space Lt 90 space
FD space 100 return then it will make a square.

Figure 15.6

Examples of Students' Handwriting from Grade 8



- 9 -

41. "Tell" a story that involves a computer. You can tell the story in words or in the form of a sequence of pictures.

We all sat there looking at
the "thing" in front of class, the
teacher was standing there motioning
for silence. We were all exeited
wondering what was under the
great white sheet, finally there
was no sound. the teacher began
to talk of the cover, it was
a computer! my friends and I
gasped it was a neat one with
a big screen & little buttons to
push, Mrs Gray began to talk she
explained how the computered
operated and how it was to be
used only for learning, we all
had the same idea in mind I guess.
No more HOMEWORK the computer
to save us from the agonizing.
HOMEWORK!

Why does the turtle move
How does the turtle move

The turtle moves because we
give it directions that it
understands.

For one learning about
Logo is really different. Working
with computers is like nothing
else I've ever done. I think its
really neat the way we can
order the turtle to do things.
The real thing they have taught
us to do is that it won't do
anything by itself. You control
it, its totally under our power.
Logo's really great and I

In most cases, children gain greater mastery over these skills with age; however, neatness or legibility of handwriting may remain rather poor into adult life. What does improve with age is the ease with which the writing can be executed. Some students who have specific learning disabilities may be able to master these skills only with great difficulty and sometimes they never do, regardless of age. Students who have neurological-muscular difficulties also experience great difficulty in developing these skills. For example, two junior-level students, one with a learning disability and the other with a deteriorating muscular condition, were still able to produce quite legible writing - but very slowly; to them it was sufficiently difficult to endure that they tried to avoid writing as much as possible. Examples of their handwriting are presented in Figure 15.7.

In using a word processor, a student must be familiar with the keyboard, preferrably have some typing skills, understand how to access, use, and exit a computer, as well as have some familiarity with features of the word processor itself. In the case of the BSW, a student must also have a minimal reading skill in order to select the appropriate category from a set menu. Except for one student in one of the Grade 1 classes, this study did not include students who had serious physical difficulties. It is important to keep in mind that the keyboard can be adapted or replaced in a variety of ways in order to meet the needs of students with various physical handicaps. When students were asked: "Compared to writing with paper and pencil, is writing with a word processor harder, easier or the same?" the responses very much depended on the relative mastery of the various skills required, and how inhibiting these skills were to the writing process. For example, among those who reported that it was the "same", the following reasons were given:

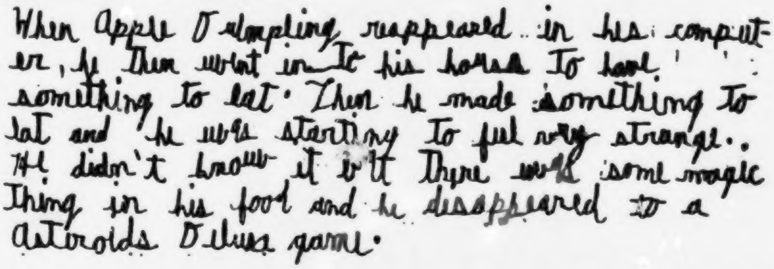
> Finding the correct keys to type is hard, but correcting errors is much easier.
>
> When I write a story it is easy to type but takes a longer time.
>
> When you write a story your hands gets tired but it takes a shorter time.
>
> It is the same in typing and writing I think because it takes just as much pressure.
>
> The same because it takes the same time for me to type as it does to write.
>
> Word processor makes the typing small but neat. Hand writing is big but not as neat.
>
> Every time you see a mistake you have to print it out again.

Among the students who found using the word processor harder, most of them had mastered their handwriting to their satisfaction; the lack of familiarity with the keyboard, typing skills, and the mechanics of using a word processor became inhibiting and interfered with their writing. Some of the reasons they gave were:

> I can write and erase much faster with pencil and eraser.

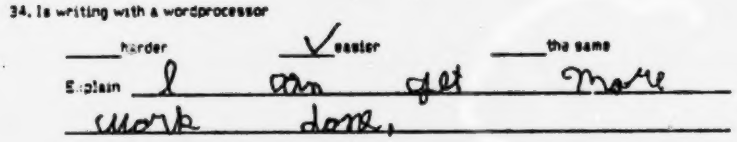
Figure 15.7

Examples of Two Junior-Level Students' Handwriting One With a Learning Disability and One With a Neuro-Muscular Disorder



When Apple Dumpling reappeared in his computer, he Then went in To his house To have
something to eat. Then he made something To
eat and he was starting To feel very strange.
He didn't know it but There was some magic
Thing in his food and he disappeared to a
Asteroids Deluxe game.

Sample of handwriting from a student with a learning disability.



34. Is writing with a wordprocessor

____ harder [✓ easier] ____ the same

Explain I can get more work done.

Sample of handwriting from a student with a neuro-muscular disorder.

> The keys are all scattered all over the board instead of in order; with a pencil you just have to write it down.
>
> You have to learn all the letters on the computer; on a piece of paper you just write.
>
> I can't type as fast as I can write.
>
> Have to use disk & wait for light.
>
> You have to learn the different controls as with hand writing I already learned them.
>
> You have to learn how to use the word processor and I already know how to use paper and pencil.
>
> You have to go through catalog and menus. Difficult to know what buttons to push to erase; with paper and pencil you just erase.
>
> You have to know a lot to change a word.
>
> Haven't got the hang of the BSW yet.
>
> I like writing with a paper and pencil, I can think of what I want in the story easier.
>
> With pencil I can just think about story.

The highest percentage of students who found the use of the word processor harder, were those of site 9b,ab (a Grade 8 class), who had spent relatively little time on the computer. Some of these students had not worked on either Logo or the BSW long enough to develop sufficient competency with the keyboard or the special features of the BSW.

The greatest number of students who found writing with the BSW to be easier compared to writing with pencil were in the Grade 3 and Grade 5/6 settings. As mentioned earlier, the predominant reason given for preferring the BSW was "my hand doesn't hurt or get tired". A complementary reason for younger students preferring the BSW was "you just have to touch the buttons and type". One Grade 5 student reported with some excitement that she was able to write her entire science project with one finger! A student who had broken his arm found this feature of great benefit since he could still keep up with his school work. For the older students the inability to type and having to learn and think about the mechanics of the word processor became more significant than the mechanics of handwriting.

The issue of teaching typing skills remained unresolved at the end of the study. A 'typing tutor' program was made available to students in the junior and intermediate grades but they were not very successful. One of the researchers during one of her class visits reported:

> I observed two children taking turns with the Typing Tutor. They were playing a game to see who could get the best score for speed and fewest errors; however, they were doing so using the "hunt and peck" method of typing. Mrs. Cook (the teacher) conceded that many of

> the children were using it in this way rather than the way intended, and she just didn't have time to supervise their activity. (Feb. 11/83)

Some of the students tried using the typing tutor with fingers on keys and eyes on the screen, but found it very frustrating. One junior-level student reported in his journal:

> I have a problem. I've tried using all my fingers for typing a story but it strains my fingers. (April 15/83)

The appearance of the final output was important to many students. Several Grade 3 students, without any prompting, stated that they preferred the BSW because "you get neater writing" and "it looks so pretty". This was mentioned even by students whose handwriting was quite "good". The concern for neatness was not restricted to the actual writing but extended to the overall appearance of the finished product. Several students, for example, mentioned that:

> Sometimes if you erase with pencil it might rip your paper.
>
> With a pencil if you make a mistake you have to erase it and it leaves a mark; with BSW you erase but it doesn't leave a mark.

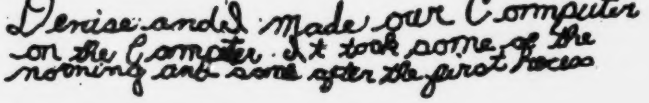
When Grade 3 students were asked if working on the computer had helped them learn other things more easily, several commented that it helped their spelling:

> If you make a mistake you can tell right away 'cause it does the wrong thing.
>
> It helps you spell because you can tell where you made a mistake; shows better because my writing isn't so good.
>
> BSW is a whole lot simpler; you print out and proofread your story. Reading writing is harder to check.
>
> BSW helps my spelling; can tell when a word doesn't look right on the screen.

The "appearance" of the word is important since children learn how to read and spell from a typewritten medium, and visual word recognition in checking spelling is an important component in developing competency in writing. The students who indicated that they had difficulty reading their own writing did not necessarily have poor handwriting. One student reported that:

> BSW helps me correct my spelling mistakes 'cause when you finish your story you like to read it over and then you notice them.

When asked whether he could not do the same thing with his handwritten work, he replied: "Yeah, but I can't read my own writing!" This particular student's handwriting was certainly not "bad" by conventional standards as can be seen below:



Denise and I made our Computer
on the Computer. It took some of the
morning and some after the first recess

One Grade 3 student found an advantage in being slowed down by the mechanics of the keyboard because she found that:

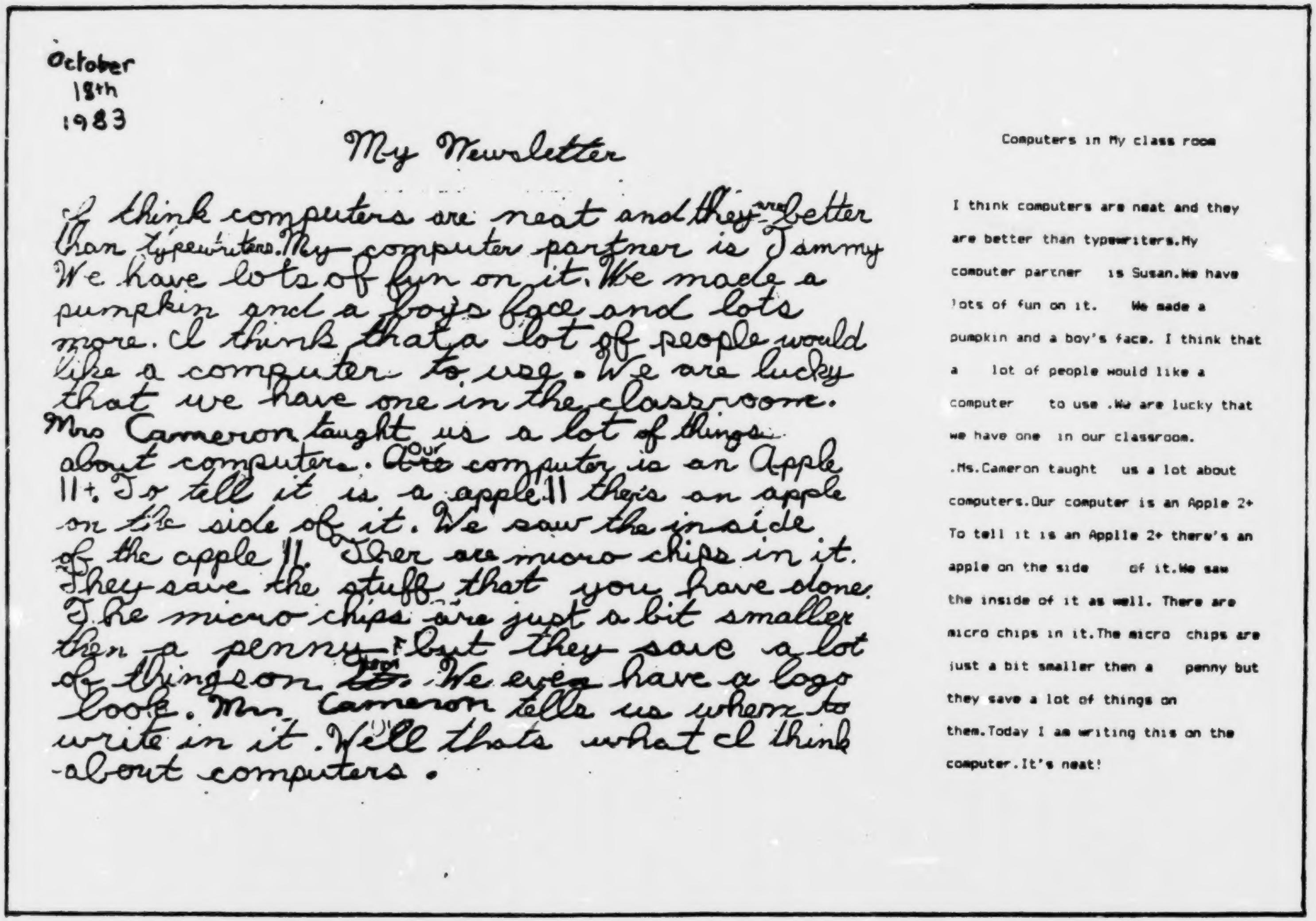
> On the BSW it is easier to notice your own mistake. On paper I go so fast I forget to look it over.

To summarize the various features mentioned to this point, Figure 15.8 compares the complete composition of a Grade 3 student written in a journal and then edited and written on the BSW. This student found the BSW easier because "my hand doesn't get tired". Another important reason why students found the BSW easier than writing with a pencil was that they found making corrections easier. The greater ease of making corrections, it was found, can encourage greater willingness to attend to spelling and improved writing styles - but it did not guarantee it. Whether students took advantage of this feature or not depended on a student's own eagerness to improve his or her spelling, on the purpose of the writing, i.e., whether it was for casual pleasure, for an assignment or for public display, and on the general "atmosphere" with respect to "good" writing set by the teacher. For example, two Grade 7 students who had no intention of sending the letter they were composing, paid little attention to format and spelling. When one of the researchers pointed out that they had missed a space between two words, they replied: "Oh, it's OK. It doesn't matter." Their letter took the following form:

```
Dear Granny & Pop
  Thankyou for the two dollars that
you gave me for my birthday.
 How is Pop and yourself I know I'm
fine.
  I hope the family and I can come and visit you and Pop very soon.
  How is David and the family were all right.


PS
I wrote this letter on the computer it save me from nombness of the fingers.
Please write back to me.  Thankyou
```

Figure 15.8

A 'Newsletter' Written by a Grade 3 Student: First by Hand and Then On the Bank Street Writer



October
18th
1983

My Newsletter

I think computers are neat and they are better than typewriters. My computer partner is Tammy We have lots of fun on it. We made a pumpkin and a boys face and lots more. I think that a lot of people would like a computer to use. We are lucky that we have one in the classroom. Mrs Cameron taught us a lot of things about computers. ~~Are~~ Our computer is an Apple 11+. To tell it is a apple 11 theis an apple on the side of it. We saw the inside of the apple 11. Ther are micro chips in it. They save the stuff that you have done. The micro chips are just a bit smaller then a penny but they save a lot of things on ~~it~~ them. We even have a logo book. Mrs. Cameron tells us where to write in it. Well thats what I think about computers.

Computers in My class room

I think computers are neat and they are better than typewriters.My computer partner is Susan.We have lots of fun on it. We made a pumpkin and a boy's face. I think that a lot of people would like a computer to use .We are lucky that we have one in our classroom. .Ms.Cameron taught us a lot about computers.Our computer is an Apple 2+ To tell it is an Applle 2+ there's an apple on the side of it.We saw the inside of it as well. There are micro chips in it.The micro chips are just a bit smaller then a penny but they save a lot of things on them.Today I am writing this on the computer.It's neat!

In general, printouts that were collected from writings on the word processor, as compared to those from writings in journals or from interactive stories or programs, show far fewer spelling mistakes. Work done on the word processor is usually printed out on paper, whereas, the text from interactive programs or stories is usually only displayed on the screen. Students do not get as much feedback from the teachers in the latter case since the teacher is not always free to observe activities on the computer. On the other hand, access to student printouts led one Grade 5 teacher to report about her students' writing on the BSW:

> The kids are anxious for me to mark their work for spelling, punctuation, etc., because they want their written work to look perfect. I set up in and out baskets for first drafts of stories. There are no hurt feelings as a result of my editing, because fixing mistakes doesn't seem like a punishment when they do it on the computer. I see a greater emphasis on the quality of their written work. (Jan. 21/83)

This teacher, who placed great value on encouraging her students to write, was very sympathetic to her students' plight of rewriting their handwritten work. Whereas, without a word processor she was reluctant to insist on a "good" final copy, she felt free to do so once her students had access to the word processor and a printer. A Grade 3 teacher (site 5) who also integrated the word processor into her daily classroom curriculum, made a point of helping students see themselves as authors. The word "proof-read" was heard frequently in the classroom on and off the computer. Her students were urged to proof-read everything and to exchange work to proof-read for each other. In order to take greater advantage of the time students had on the computer, this teacher encouraged students to write a preliminary draft of their assignments in their workbooks, type it into the computer and then proceed to proof-read and edit it. Some students found that the BSW made it:

> ... easier if you make a mistake. You don't have to redo it.
>
> ... easier to get back to where you made the mistake to fix it.

During an interview, a Grade 3 student indicated that:

> The BSW helps me spell more better. When I misspell a word I look it up in the dictionary, correct it and next time I know how to spell it.

When he was asked whether he could not do this when writing with a pencil, he replied: "Yes, but the BSW is more fun!" When students were asked whether they worried more, less, or the same about making mistakes on the word processor than when they write with a pencil, only 35% of the Grade 3 students reported that they were "more" concerned. This percentage was even smaller for students in the other classes. Some of the Grade 3 students who indicated "more" concern over making mistakes, included among them, concerns over making typing mistakes and of being unsure as to "what buttons to push" for editing in the Bank Street Writer. Corrections in students' written work were generally of two main types:

1) correcting spelling, typing, grammatical and stylistic mistakes (Figure 15.9);
2) inserting, deleting or re-writing text (Figure 15.10).

When students were asked whether the stories they write on the word processor were longer, shorter, or the same, 70% of the Grade 3 students reported that their stories were shorter. It became clear through further questioning (this was not done in the upper grades), that "shorter" for many of the students was a spatial perception rather than the number of words written. Several commented that:

> It takes up less space; number of words the same.
>
> Takes up more room with paper and pencil.
>
> On the screen it looks longer than it is.
>
> When you print it out you get more words on a line.
>
> The screen is longer and you can get more on than on one line of paper. Number of words the same.

In Grade 5, assignments that were open-ended (such as a letter to a penpal or a survival story from the point of view of the animal) varied in length between 6 and 24 typewritten lines and 7 and 38 typewritten lines respectively. It is difficult to speculate whether this is longer or shorter than it would have been if the students had written their assignments by hand. The classroom teacher felt that their work tended to be longer, and one of the students once related to one of the researchers during a class visit that:

> I like working with the BSW. It's much easier than writing stories by hand and not so boring. You write more because you don't realize how much you are doing. (Oct. 21/83)

Another unexpected perception among some of the Grade 3 students was that they wrote shorter stories because:

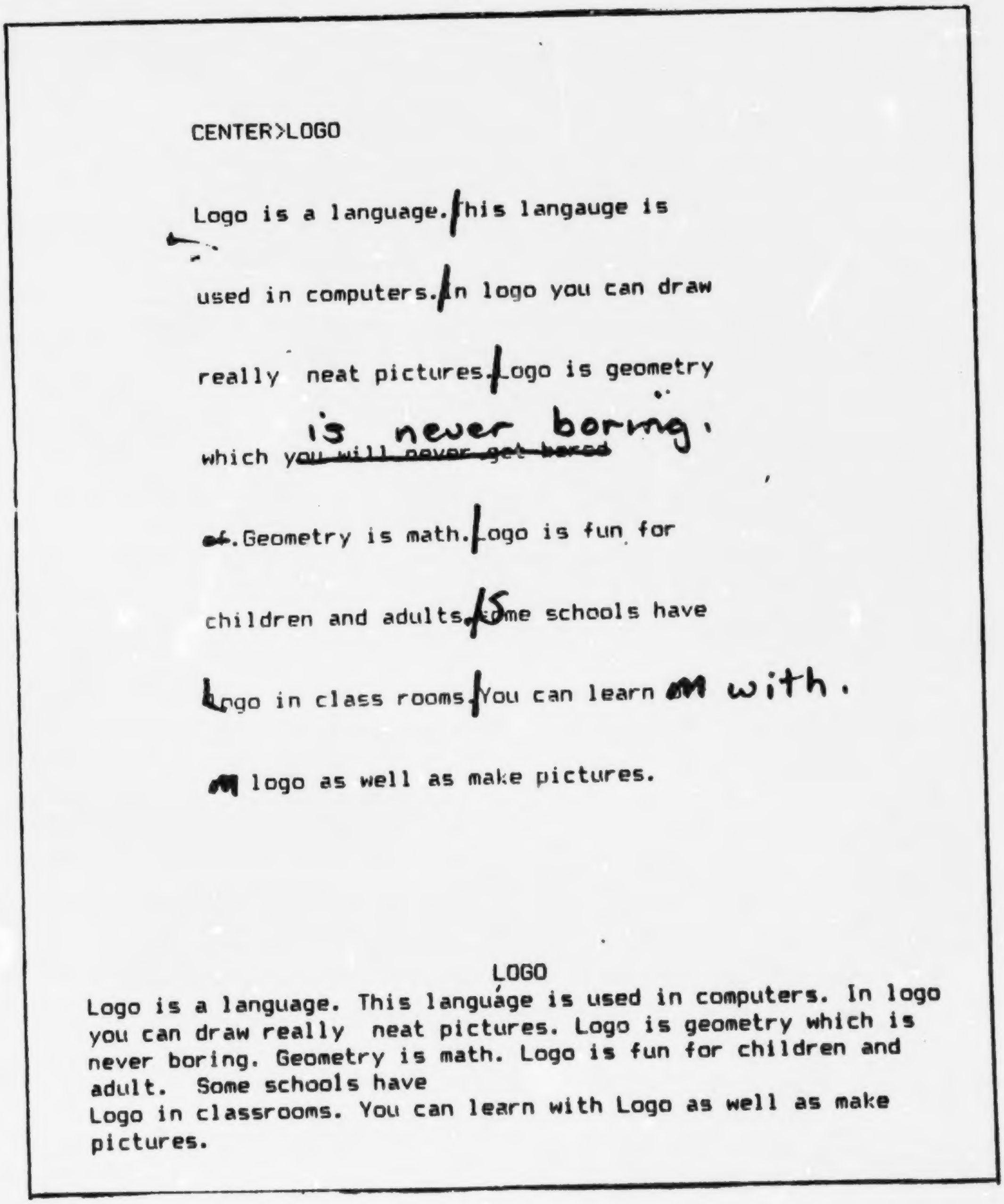
> ... the screen is only this big.
>
> Screen is smaller than a piece of paper.
>
> Don't have lots of room on computer but have lots of paper.

Other reasons for writing shorter stories made reference to the mechanics of typing and printing:

> Can't think as much and I get tired of pushing the keys.
>
> Finding letters slows you down.
>
> I don't think of long things to do. It takes too long to print out. My last handwritten story was four pages long.
>
> Get tired of typing.

Figure 15.9

An Example of a Draft Copy and Final Copy of a Written Account of Logo Produced by a Grade 5 Student Using the Bank Street Writer



CENTER>LOGO

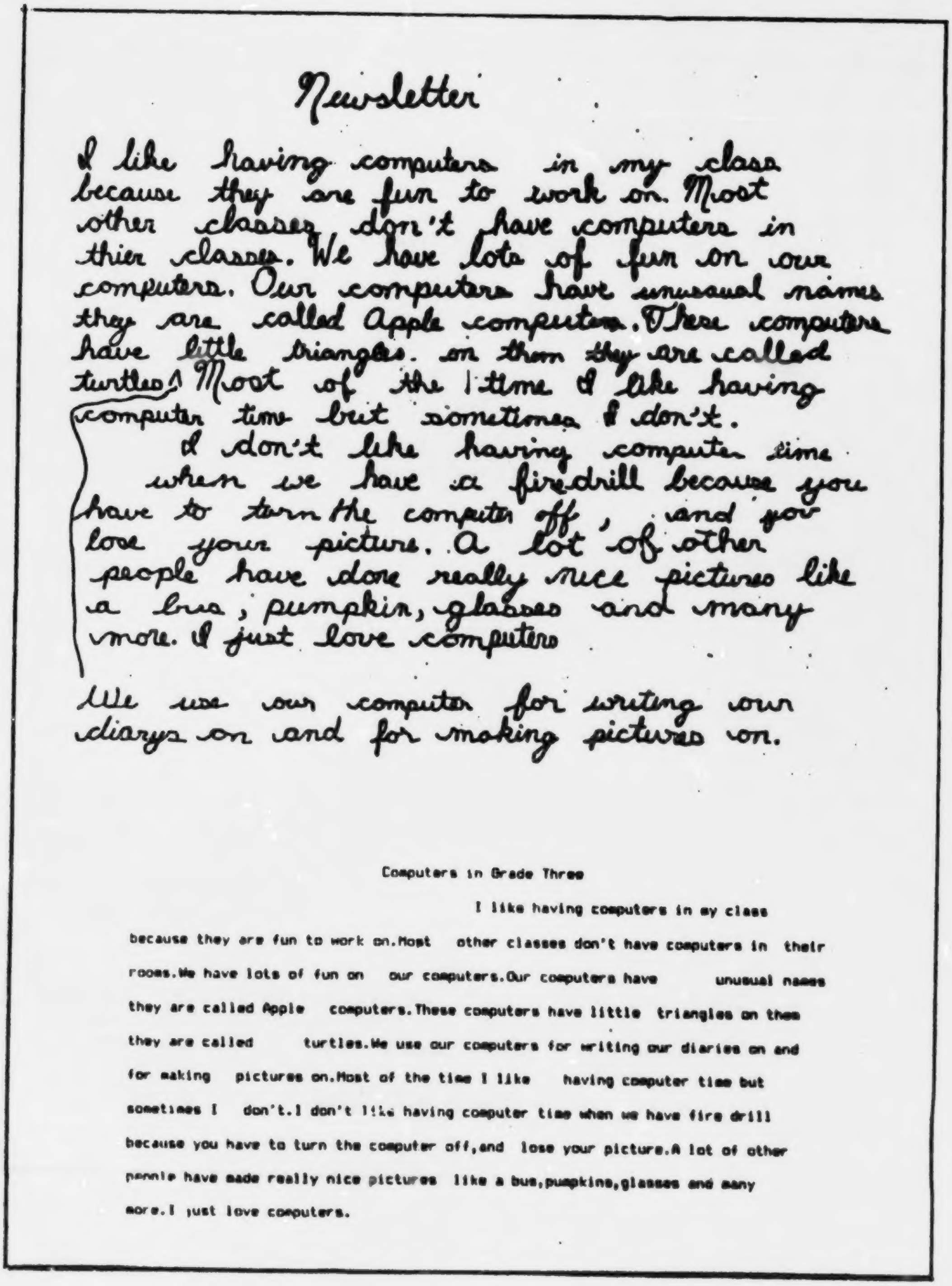
Logo is a language. This langauge is used in computers. In logo you can draw really neat pictures. Logo is geometry which ~~you will never get bored~~ is never boring. ~~of~~. Geometry is math. Logo is fun for children and adults. Some schools have Logo in class rooms. You can learn [illegible] with. [illegible] logo as well as make pictures.

LOGO

Logo is a language. This language is used in computers. In logo you can draw really neat pictures. Logo is geometry which is never boring. Geometry is math. Logo is fun for children and adult. Some schools have
Logo in classrooms. You can learn with Logo as well as make pictures.

Figure 15.10

An Example from a Grade 3 Class of a Draft Copy Produced by Hand, and a Final Copy Produced on the Bank Street Writer That Depicts Editing by Inserting Text



Newsletter

I like having computers in my class because they are fun to work on. Most other classes don't have computers in thier classes. We have lots of fun on our computers. Our computers have unusaual names they are called Apple computers. These computers have little triangles. on them they are called turtles. Most of the time I like having computer time but sometimes I don't.

I don't like having computer time when we have a firedrill because you have to turn the computer off, and you lose your picture. A lot of other people have done really nice pictures like a bus, pumpkin, glasses and many more. I just love computers

We use our computer for writing our diarys on and for making pictures on.

Computers in Grade Three

I like having computers in my class because they are fun to work on.Most other classes don't have computers in their rooms.We have lots of fun on our computers.Our computers have unusual names they are called Apple computers.These computers have little triangles on them they are called turtles.We use our computers for writing our diaries on and for making pictures on.Most of the time I like having computer time but sometimes I don't.I don't like having computer time when we have fire drill because you have to turn the computer off,and lose your picture.A lot of other people have made really nice pictures like a bus,pumpkins,glasses and many more.I just love computers.

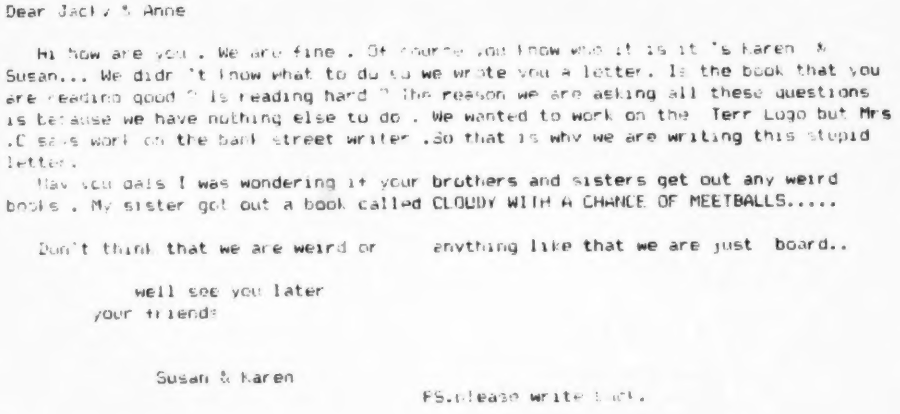
A few of the older students when asked whether they preferred a word processor or writing by hand indicated no particular preference because:

> On the word processor you still have to think and write.
>
> I think it is the same because it contains the same thinking for it.

Whether students are encouraged to write more or less with a word processor seemed to depend very much on the ability and imagination of students. For example, some journal entries by Grade 5/6 students who spent a lot of time with the BSW and who sometimes had to use the BSW during their free exploration time, show that the primary difficulty still lies with the imagination of the students and the difficulty of being creative on command:

> When I am on the W.P. I don't know what to write.
>
> I hate word processing because when I'm on I don't know what to write about.
>
> We went on the WP for 2 hours. We wrote notes the whole time and fooled around. The second time we had to write a "closet" story. It was pretty boring.
>
> BSW this week was boring - I had to fix my plot and my story. Maria's story is really exciting. I always have boring stories.

The following is an example of "sending notes to each other":



Dear Jacky & Anne

Hi how are you . We are fine . Of course you know who it is it 's Karen & Susan... We didn 't know what to do so we wrote you a letter. Is the book that you are reading good ? Is reading hard ? The reason we are asking all these questions is because we have nothing else to do . We wanted to work on the Terr Logo but Mrs .C says work on the bank street writer .So that is why we are writing this stupid letter.

Hay you gals I was wondering if your brothers and sisters get out any weird books . My sister got out a book called CLOUDY WITH A CHANCE OF MEETBALLS.....

Don't think that we are weird or anything like that we are just board..

well see you later
your friends

Susan & Karen

PS.please write back.

Students in all grades sometimes spent their "free exploration time" copying excerpts from books. However, a student from the junior-level class wrote "I like the BSW because I like writing stories". He made a special request of his teacher to allow him to do more than just assignments on the word processor:

> Dear Mrs.Cook
>
> Well I guess I'd want to use it for creative language but I'd like to do projects on it to because it would be easier doing it on here because you can correct easily and you can print it on the printer and its so much neater. When your finished and I'd like to do projects on it because it would be a lot faster.But when im not doinq a project or something like that you would probably find me doing Dungeons & Dragons storys.Well thats all folks!
>
> SINCERELY Ian Livingston

He and his partner wrote a 56-page story which, they claim, they would not have written if they had had to do it by hand.

When students were asked whether they preferred working on a word processor (alone, with your partner, or not at all), 65% of Grade 3 students indicated that they preferred working with a partner, while 90% of the Grade 5 students indicated that they preferred working alone. In the other two classes, the students who had been in the study for two years were almost evenly split between working alone or with a partner, but the students who were new to the study in the second year showed a preference for working alone. Some reasons that Grade 3 students gave for preferring to work with a partner were:

> Because if I make a mistake my partner can tell me what I did.
>
> Take turns writing; I'll type one line then she types one line.
>
> When you are wrong he can help you.
>
> Sometimes he really helps. When I can't figure out how to spell a word, he might know how to.
>
> I can be typing and he can see a mistake that I didn't.
>
> Share ideas.
>
> Because then we get to do the story together and we may think of different things to put in the story.

Those who indicated that they wanted to work alone gave the following reasons:

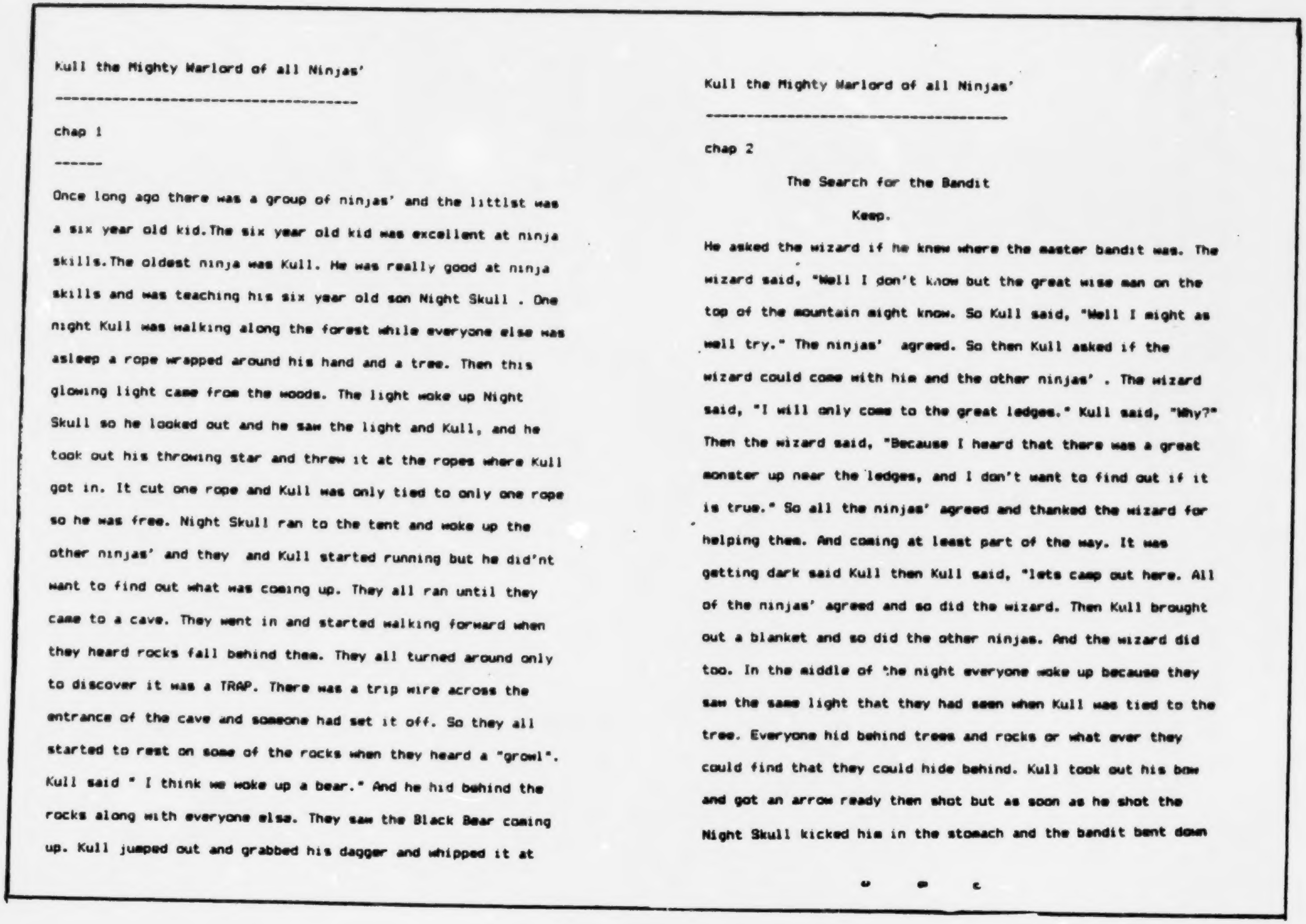
> Because my partner will find the key for me and I'd rather do it myself.
>
> Have more privacy.

> They make up ideas that don't make sense in the story.
>
> Own story instead of two ideas.

The pair of junior-level students mentioned earlier, who wrote the 56-page story, worked out an ingenious strategy for writing it. They would discuss the beginning and end of each chapter together, and then alternately write the body of each chapter. A brief excerpt from their story is given in Figure 15.11.

Figure 15.11

Excerpts From a 56-Page Novel Written by Two Grade 6 Students Using the Bank Street Writer



Kull the Mighty Warlord of all Ninjas'

----

chap 1

Once long ago there was a group of ninjas' and the littlst was a six year old kid.The six year old kid was excellent at ninja skills.The oldest ninja was Kull. He was really good at ninja skills and was teaching his six year old son Night Skull . One night Kull was walking along the forest while everyone else was asleep a rope wrapped around his hand and a tree. Then this glowing light came from the woods. The light woke up Night Skull so he looked out and he saw the light and Kull, and he took out his throwing star and threw it at the ropes where Kull got in. It cut one rope and Kull was only tied to only one rope so he was free. Night Skull ran to the tent and woke up the other ninjas' and they and Kull started running but he did'nt want to find out what was coming up. They all ran until they came to a cave. They went in and started walking forward when they heard rocks fall behind them. They all turned around only to discover it was a TRAP. There was a trip wire across the entrance of the cave and someone had set it off. So they all started to rest on some of the rocks when they heard a "growl". Kull said " I think we woke up a bear." And he hid behind the rocks along with everyone else. They saw the Black Bear coming up. Kull jumped out and grabbed his dagger and whipped it at

Kull the Mighty Warlord of all Ninjas'

----

chap 2

The Search for the Bandit

Keep.

He asked the wizard if he knew where the master bandit was. The wizard said, "Well I don't know but the great wise man on the top of the mountain might know. So Kull said, "Well I might as well try." The ninjas' agreed. So then Kull asked if the wizard could come with him and the other ninjas' . The wizard said, "I will only come to the great ledges." Kull said, "Why?" Then the wizard said, "Because I heard that there was a great monster up near the ledges, and I don't want to find out if it is true." So all the ninjas' agreed and thanked the wizard for helping them. And coming at least part of the way. It was getting dark said Kull then Kull said, "lets camp out here. All of the ninjas' agreed and so did the wizard. Then Kull brought out a blanket and so did the other ninjas. And the wizard did too. In the middle of the night everyone woke up because they saw the same light that they had seen when Kull was tied to the tree. Everyone hid behind trees and rocks or what ever they could find that they could hide behind. Kull took out his bow and got an arrow ready then shot but as soon as he shot the Night Skull kicked him in the stomach and the bandit bent down

16. LOGO TEXT AND INTERACTIVE STORIES

Whereas the computer and a word processor facilitate the mechanics of writing, they do not significantly change the nature of the writing process. The use of the word and list properties of the Logo language, however, potentially add a new dynamic dimension to the use of language. Words and sentences can be taken apart with BUTFIRST or BUTLAST statements, and interactive procedures using text as input become possible. These features allow students to play with language in a way they have not been able to do before. For many students, this became an interesting new domain to explore. When interactive programming was first introduced, the atmosphere in the classroom was usually alive with excitement. As one junior-level student recorded in his journal:

> It's funner to work with words than it is to work with graphics. (April 1983)

The teachers tended to introduce the text handling features to students rather late in the school year. This decision was based partly on the fact that the programming of interactive text is more complicated than that for graphics, and partly on the reluctance of the teachers to introduce procedures to students that they did not understand themselves. The teachers often didn't have the time or inclination to explore this dimension of the language. By the end of the first year of the study, words and lists were used by one Grade 5 class and by one Grade 6/7 class. Because they could not find the time to further their own knowledge in this area, the teachers of these two clases did not build on these concepts during the second year, even though they had continuing students in the class. Towards the end of the second year, a Grade 3 teacher began to use a procedure called CHAT as a tool for her students, and the Grade 5/6 teacher introduced students to writing interactive stories (using materials developed by Peter Skillen of the Board of Education of the City of North York, near Toronto). Students in Grade 7 used some interactive procedures but only to a limited extent. Students reacted not only to the delights of working with language but also to having a break from the graphics which they had used for most of the school year.

The easiest way to use text within Logo procedures was to use PRINT statements. This required little additional knowledge beyond graphics procedures and students could learn to incorporate those statements without much difficulty. Examples of activities that make use of PRINT statements are:

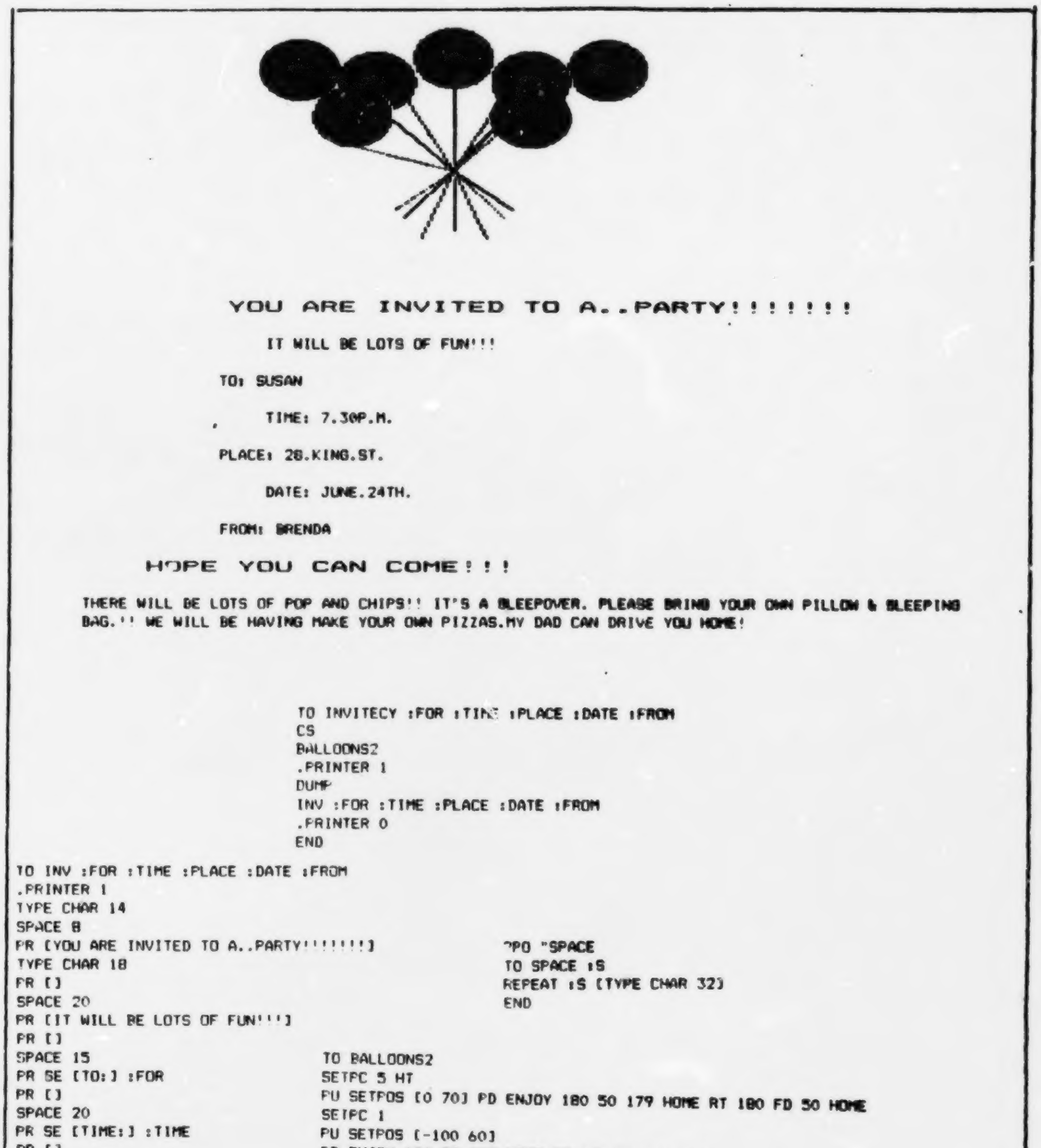
1) adding titles or explanations to graphics output;
2) using the font capability of the printer to write an invitation (Figure 16.1); and
3) combining graphics and text in a story to be shown on the screen (Figures 16.2 and 16.3).

The simplest form of Logo word play, in the sense that it requires few additional programming skills, is one of arranging words in different formats using the CURSOR primitive (which makes it possible to place letters in different locations on the screen or page). Another relatively simple form is through the use of the primitives BUTFIRST, which can take words apart, or DOUBLE, which can put words together. Interactive procedures that respond to keyboard input are somewhat more difficult to construct. Additional programming commands must be learned and the logic of the procedures is often not obvious. Even though some students familiarized themselves with the new programming primitives, most tended to use and adapt procedures given to them by their teachers. One of these procedures was CHAT, which allowed students to set a series of questions and accept a set of possible answers. Some Grade 3 as well as Grade 8 students enjoyed this activity. Examples of their work may be seen in Figure 16.4. A further extension of this was the interactive story which used blocks of stories or text as procedural input. This could be combined with graphics to provide an integrated story on the screen. Only the Grade 5/6 students engaged in this activity (Figures 16.5 and 16.6).

Potentially exciting, but an area that was only touched on by one of the Grade 5 teachers, was the use of Logo procedures for poetry and grammatical explorations. One of the procedures TO RHYME.WITH.PLAY evaluates whether words rhyme with a given word. One may also use list procedures for creating categories, such as adjectives, nouns, and verbs, and then generate sentences either systematically or randomly by choosing words from the different categories. This can create both sense and nonsense sentences. Through the unexpected and incongruous (humorous), students can become more aware of the structure of their language. Two of the intermediate level teachers felt that, in the future, they would expand this side of Logo to a much larger extent but they were not able to do so during the course of the present study.

Figure 16.1

An Example of an Invitation to a Party Using Logo and the Different Font Capabilities of the Printer; Produced by Grade 6 Students

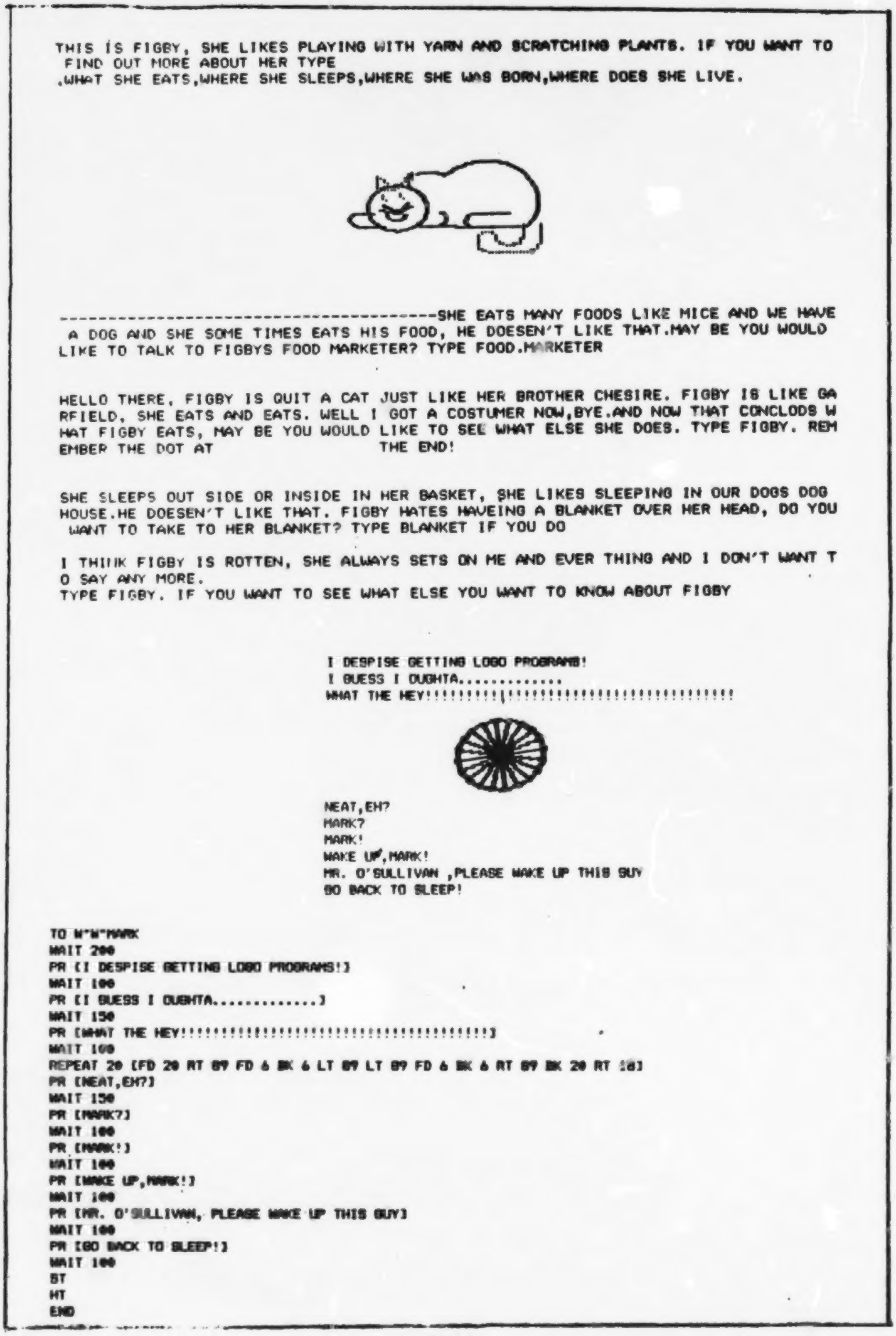


```
        YOU ARE INVITED TO A..PARTY!!!!!!!

             IT WILL BE LOTS OF FUN!!!

        TO: SUSAN

             TIME: 7.30P.M.

        PLACE: 28.KING.ST.

             DATE: JUNE.24TH.

        FROM: BRENDA

    HOPE YOU CAN COME!!!

THERE WILL BE LOTS OF POP AND CHIPS!! IT'S A SLEEPOVER. PLEASE BRING YOUR OWN PILLOW & SLEEPING
BAG.!! WE WILL BE HAVING MAKE YOUR OWN PIZZAS.MY DAD CAN DRIVE YOU HOME!
```

```
                               TO INVITECY :FOR :TIME :PLACE :DATE :FROM
                               CS
                               BALLOONS2
                               .PRINTER 1
                               DUMP
                               INV :FOR :TIME :PLACE :DATE :FROM
                               .PRINTER 0
                               END
TO INV :FOR :TIME :PLACE :DATE :FROM
.PRINTER 1
TYPE CHAR 14
SPACE 8
PR [YOU ARE INVITED TO A..PARTY!!!!!!!]              ?PO "SPACE
TYPE CHAR 18                                         TO SPACE :S
PR []                                                REPEAT :S [TYPE CHAR 32]
SPACE 20                                             END
PR [IT WILL BE LOTS OF FUN!!!]
PR []
SPACE 15                         TO BALLOONS2
PR SE [TO:] :FOR                 SETPC 5 HT
PR []                            PU SETPOS [0 70] PD ENJOY 180 50 179 HOME RT 180 FD 50 HOME
SPACE 20                         SETPC 1
PR SE [TIME:] :TIME              PU SETPOS [-100 60]
PR []                            PD ENJOY 180 50 179 HOME RT 130 FD 50 HOME
SPACE 15                         SETPC 3
PR SE [PLACE:] :PLACE            PU SETPOS [100 60] PD ENJOY 180 50 179 HOME LT 130 FD 50 PU HOME HT
PR []                            SETPC 2
SPACE 20                         PU SETPOS [-50 50] PD ENJOY 180 50 179 HOME RT 160 FD 60 PU HOME
PR SE [DATE:] :DATE              SETPC 4
PR []                            PU
SPACE 15                         SETPOS [50 50] PD ENJOY 180 50 179 HOME
PR SE [FROM:] :FROM              LT 160 PD FD 60 PU HOME PD
PR []                            PU SETPOS [50 20] PD SETPC 1 ENJOY 180 50 179 HOME LT 140 FD 50
SPACE 7                          PU SETPOS [-50 65] PD SETPC 3 ENJOY 180 50 179 HOME RT 140 FD 50 PU HOME PD
TYPE CHAR 14                     END
PR [HOPE YOU CAN COME!!!]
TYPE CHAR 18
PR []
PR [THERE WILL BE LOTS OF POP AND CHIPS!! IT'S A SLEEPOVER. PLEASE BRING YOUR OWN PILLOW & SLEEP
ING BAG.!! WE WILL BE HAVING MAKE YOUR OWN PIZZA3.MY DAD CAN DRIVE YOU HOME!]
.PRINTER 0
END
```

Figure 16.2

An Example of a Printout of an Executed Procedure and a Procedure Written in Logo that Combine Graphics and PRINT Statements; Both Created by Two Grade 6 Students



```
THIS IS FIGBY, SHE LIKES PLAYING WITH YARN AND SCRATCHING PLANTS. IF YOU WANT TO
 FIND OUT MORE ABOUT HER TYPE
,WHAT SHE EATS,WHERE SHE SLEEPS,WHERE SHE WAS BORN,WHERE DOES SHE LIVE.
```

```
---------------------------------------SHE EATS MANY FOODS LIKE MICE AND WE HAVE
 A DOG AND SHE SOME TIMES EATS HIS FOOD, HE DOESEN'T LIKE THAT.MAY BE YOU WOULD
LIKE TO TALK TO FIGBYS FOOD MARKETER? TYPE FOOD.MARKETER


HELLO THERE, FIGBY IS QUIT A CAT JUST LIKE HER BROTHER CHESIRE. FIGBY IS LIKE GA
RFIELD, SHE EATS AND EATS. WELL I GOT A COSTUMER NOW,BYE.AND NOW THAT CONCLODS W
HAT FIGBY EATS, MAY BE YOU WOULD LIKE TO SEE WHAT ELSE SHE DOES. TYPE FIGBY. REM
EMBER THE DOT AT                    THE END!


SHE SLEEPS OUT SIDE OR INSIDE IN HER BASKET, SHE LIKES SLEEPING IN OUR DOGS DOG
HOUSE.HE DOESEN'T LIKE THAT. FIGBY HATES HAVEING A BLANKET OVER HER HEAD, DO YOU
 WANT TO TAKE TO HER BLANKET? TYPE BLANKET IF YOU DO

I THINK FIGBY IS ROTTEN, SHE ALWAYS SETS ON ME AND EVER THING AND I DON'T WANT T
O SAY ANY MORE.
TYPE FIGBY. IF YOU WANT TO SEE WHAT ELSE YOU WANT TO KNOW ABOUT FIGBY
```

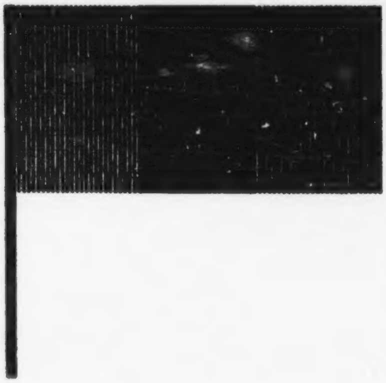
```
I DESPISE GETTING LOGO PROGRAMS!
I GUESS I OUGHTA..............
WHAT THE HEY!!!!!!!!!!|!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
```

```
NEAT,EH?
MARK?
MARK!
WAKE UP,MARK!
MR. O'SULLIVAN ,PLEASE WAKE UP THIS GUY
GO BACK TO SLEEP!
```

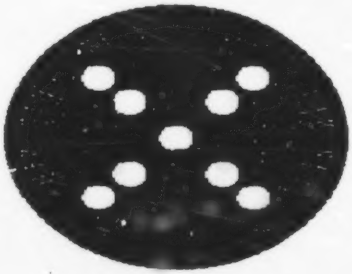
```
TO W"W"MARK
WAIT 200
PR [I DESPISE GETTING LOGO PROGRAMS!]
WAIT 100
PR [I GUESS I OUGHTA.............]
WAIT 150
PR [WHAT THE HEY!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!]
WAIT 100
REPEAT 20 [FD 20 RT 89 FD 6 BK 6 LT 89 LT 89 FD 6 BK 6 RT 89 BK 20 RT 18]
PR [NEAT,EH?]
WAIT 150
PR [MARK?]
WAIT 100
PR [MARK!]
WAIT 100
PR [WAKE UP,MARK!]
WAIT 100
PR [MR. O'SULLIVAN, PLEASE WAKE UP THIS GUY]
WAIT 100
PR [GO BACK TO SLEEP!]
WAIT 100
ST
HT
END
```

Figure 16.3

Two Samples of Procedures Written in Logo that Combine Graphics and PRINT Statements; Collected from a Grade 6/7 Class



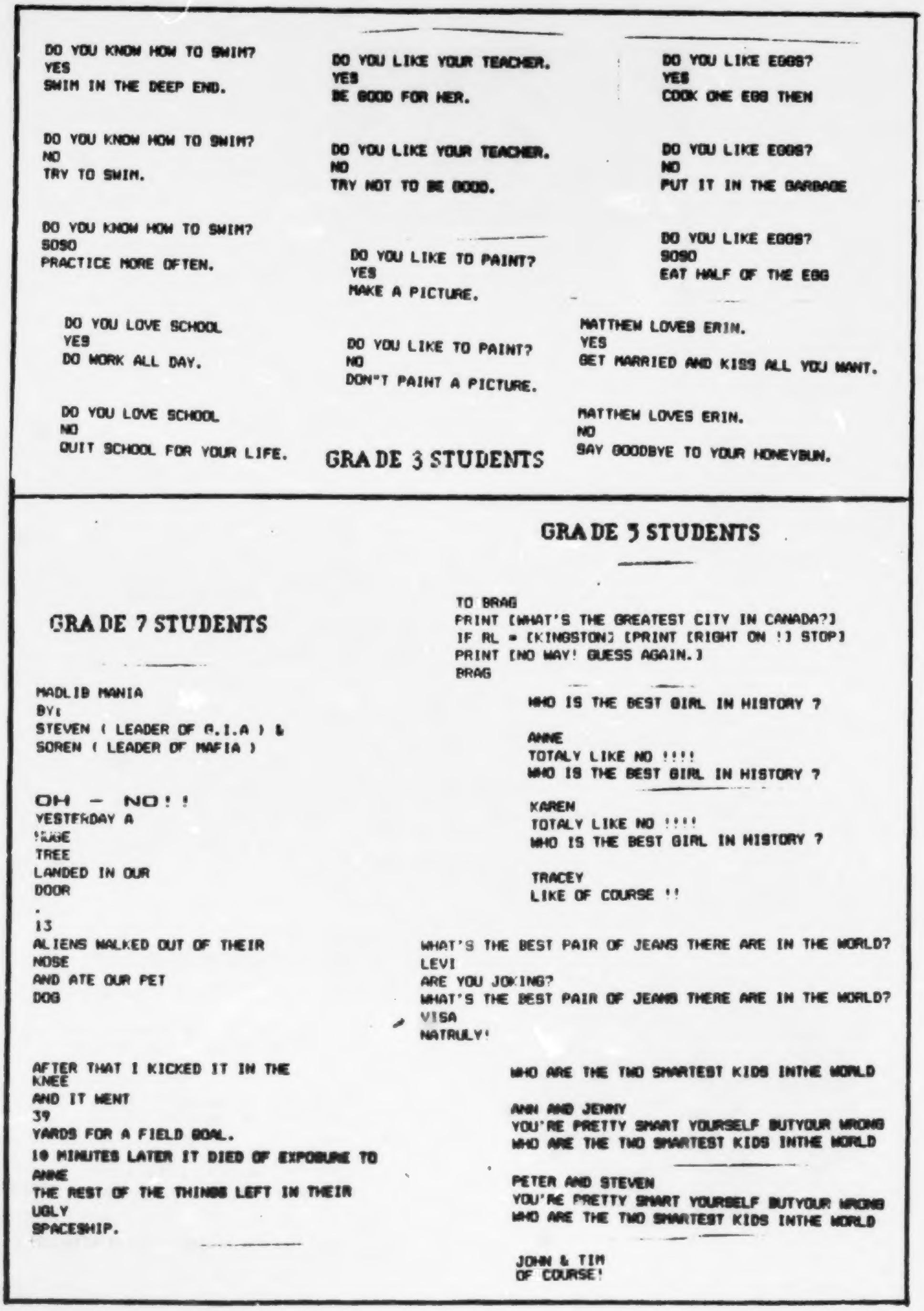
```
TO ANTHEM
PR [OH CANADA ']
WAIT 100
PR [OUR HOME AND NATIVE LAND]
WAIT 125
PR [TRUE PATRIOT LOVE]
WAIT 100
PR [IN ALL THY SONS COMMAND]
WAIT 100
PR [WITH GLOWING HEARTS WE SEE THEE RISE THE TRUE NORTH STRONG AND FREE]
WAIT 150
PR [FROM FAR AND WIDE OH CANADA WE STAND ON GUARD FOR THEE]
WAIT 150
PR [GOD KEEP OUR LAND GLORIOUS AND FREE]
WAIT 150
PR [OH CANADA]
WAIT 100
PR [WE STAND ON GUARD FOR THEE]
WAIT 100
PR [OH CANADA]
WAIT 100
PR [WE STAND ON GUARD FOR THEE]
END
```



```
TO PIZZA1
PR [TODAY WE ARE GOING TO MAKE A PIZZA]
WAIT 100
PR [FIRST WE START OUT WITH THE DOUGH]
WAIT 100
ST HT REPEAT 360 [FD 110 BK 110 RT 1]
PR [NEXT WE PUT ON THE TOMATO SAUCE]
WAIT 100
SETPC 4
REPEAT 360 [FD 100 BK 100 RT 1]
PR [NOW WE PUT ON THE PEPPERONIES]
WAIT 100
PEP
PR [SORRY THEY WERE A LITTLE BURNT]
PR [AND FINALLY WE PUT ON THE GREEN PEPPERS]
WAIT 100
PEPP
PR [THANK YOU FOR MAKING A PIZZA WITH US]
END
```

Figure 16.4

Examples of Printouts of Executed Procedures Written in Logo by a Grade 3, a Grade 5, and a Grade 7 Student Based on the Interactive Text Procedure 'CHAT'



GRADE 3 STUDENTS

```
DO YOU KNOW HOW TO SWIM?
YES
SWIM IN THE DEEP END.

DO YOU KNOW HOW TO SWIM?
NO
TRY TO SWIM.

DO YOU KNOW HOW TO SWIM?
SOSO
PRACTICE MORE OFTEN.

DO YOU LOVE SCHOOL
YES
DO WORK ALL DAY.

DO YOU LOVE SCHOOL
NO
QUIT SCHOOL FOR YOUR LIFE.
```

```
DO YOU LIKE YOUR TEACHER.
YES
BE GOOD FOR HER.

DO YOU LIKE YOUR TEACHER.
NO
TRY NOT TO BE GOOD.

DO YOU LIKE TO PAINT?
YES
MAKE A PICTURE.

DO YOU LIKE TO PAINT?
NO
DON"T PAINT A PICTURE.
```

```
DO YOU LIKE EGGS?
YES
COOK ONE EGG THEN

DO YOU LIKE EGGS?
NO
PUT IT IN THE GARBAGE

DO YOU LIKE EGGS?
SOSO
EAT HALF OF THE EGG

MATTHEW LOVES ERIN.
YES
GET MARRIED AND KISS ALL YOU WANT.

MATTHEW LOVES ERIN.
NO
SAY GOODBYE TO YOUR HONEYBUN.
```

GRADE 5 STUDENTS

```
TO BRAG
PRINT [WHAT'S THE GREATEST CITY IN CANADA?]
IF RL = [KINGSTON] [PRINT [RIGHT ON !] STOP]
PRINT [NO WAY! GUESS AGAIN.]
BRAG
```

```
WHO IS THE BEST GIRL IN HISTORY ?

ANNE
TOTALY LIKE NO !!!!
WHO IS THE BEST GIRL IN HISTORY ?

KAREN
TOTALY LIKE NO !!!!
WHO IS THE BEST GIRL IN HISTORY ?

TRACEY
LIKE OF COURSE !!
```

```
WHAT'S THE BEST PAIR OF JEANS THERE ARE IN THE WORLD?
LEVI
ARE YOU JOKING?
WHAT'S THE BEST PAIR OF JEANS THERE ARE IN THE WORLD?
VISA
NATRULY!
```

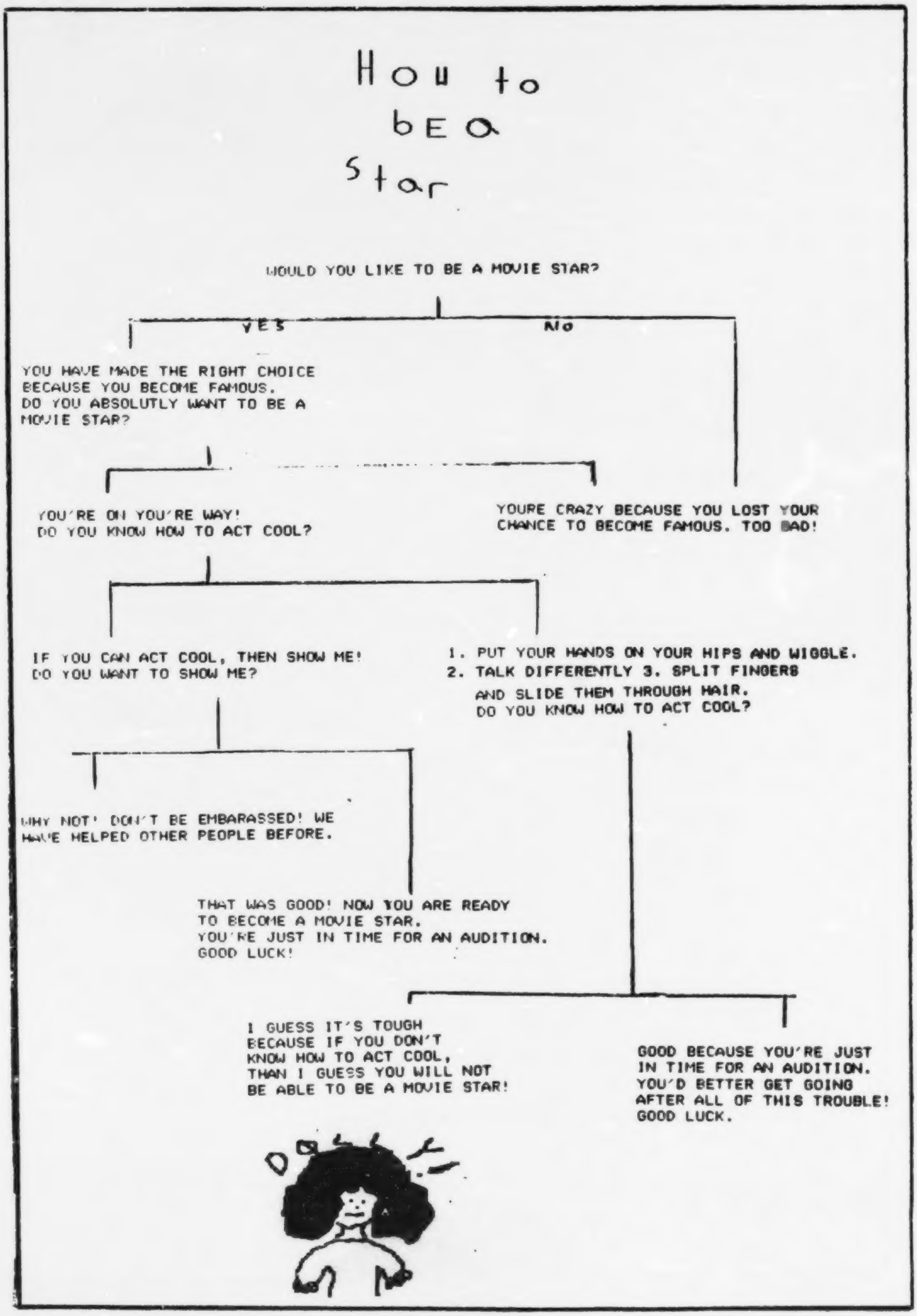
```
WHO ARE THE TWO SMARTEST KIDS INTHE WORLD

ANN AND JENNY
YOU'RE PRETTY SMART YOURSELF BUTYOUR WRONG
WHO ARE THE TWO SMARTEST KIDS INTHE WORLD

PETER AND STEVEN
YOU'RE PRETTY SMART YOURSELF BUTYOUR WRONG
WHO ARE THE TWO SMARTEST KIDS INTHE WORLD

JOHN & TIM
OF COURSE!
```

GRADE 7 STUDENTS

```
MADLIB MANIA
BY:
STEVEN ( LEADER OF G.I.A ) &
SOREN ( LEADER OF MAFIA )


OH - NO!!
YESTERDAY A
HUGE
TREE
LANDED IN OUR
DOOR
.
13
ALIENS WALKED OUT OF THEIR
NOSE
AND ATE OUR PET
DOG


AFTER THAT I KICKED IT IN THE
KNEE
AND IT WENT
39
YARDS FOR A FIELD GOAL.
10 MINUTES LATER IT DIED OF EXPOSURE TO
ANNE
THE REST OF THE THINGS LEFT IN THEIR
UGLY
SPACESHIP.
```

Figure 16.5

'How To Be A Star': A Printout of an Executed Procedure Written in Logo as an Interactive Story (Graphics Done On Koala Pad), Created by a Girl in a Grade 5 Class



How to
bea
Star

WOULD YOU LIKE TO BE A MOVIE STAR?

YOU HAVE MADE THE RIGHT CHOICE
BECAUSE YOU BECOME FAMOUS.
DO YOU ABSOLUTLY WANT TO BE A
MOVIE STAR?

YOU'RE ON YOU'RE WAY!
DO YOU KNOW HOW TO ACT COOL?

YOURE CRAZY BECAUSE YOU LOST YOUR
CHANCE TO BECOME FAMOUS. TOO BAD!

IF YOU CAN ACT COOL, THEN SHOW ME!
DO YOU WANT TO SHOW ME?

1. PUT YOUR HANDS ON YOUR HIPS AND WIGGLE.
2. TALK DIFFERENTLY 3. SPLIT FINGERS
AND SLIDE THEM THROUGH HAIR.
DO YOU KNOW HOW TO ACT COOL?

WHY NOT! DON'T BE EMBARASSED! WE
HAVE HELPED OTHER PEOPLE BEFORE.

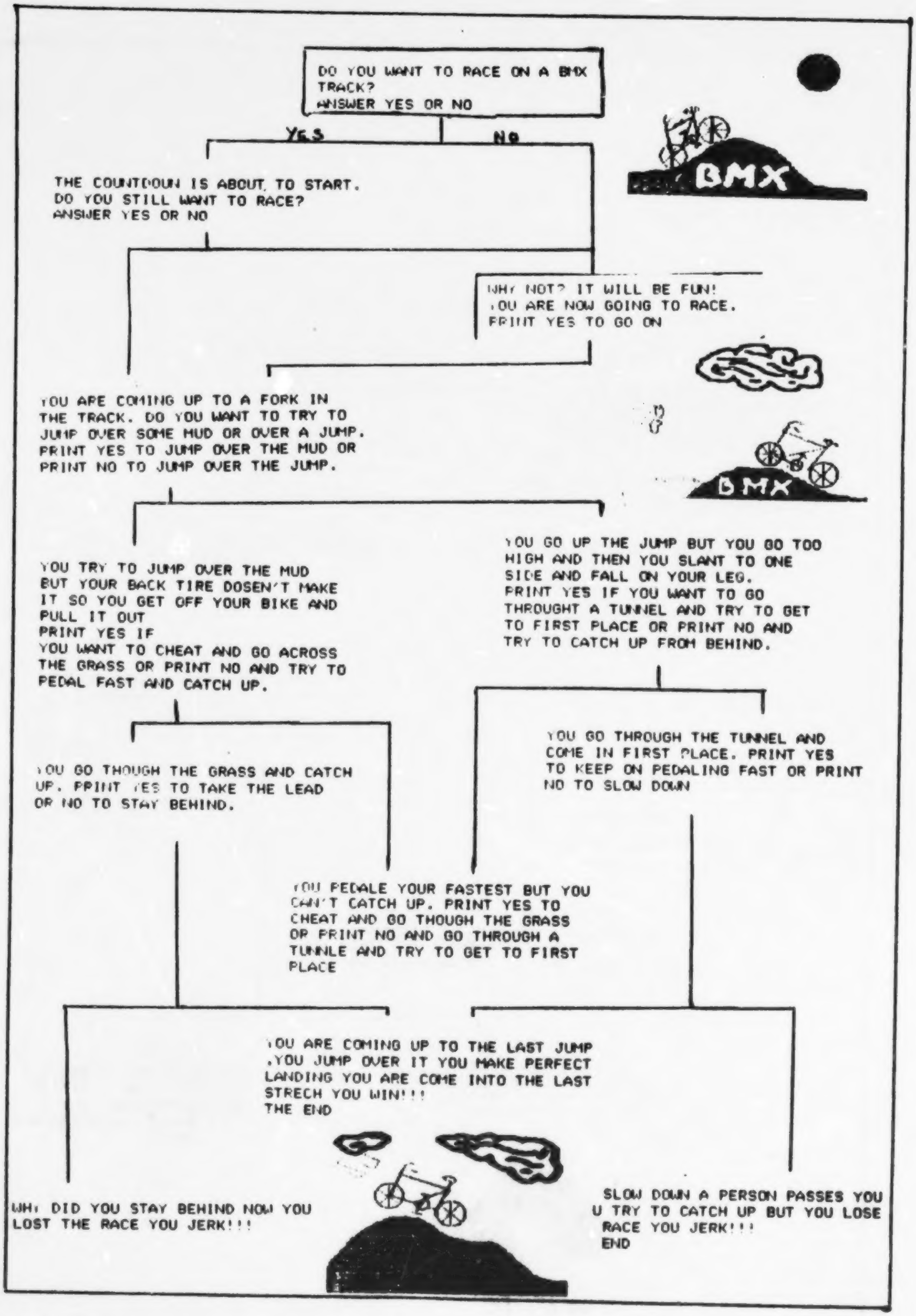
THAT WAS GOOD! NOW YOU ARE READY
TO BECOME A MOVIE STAR.
YOU'RE JUST IN TIME FOR AN AUDITION.
GOOD LUCK!

I GUESS IT'S TOUGH
BECAUSE IF YOU DON'T
KNOW HOW TO ACT COOL,
THAN I GUESS YOU WILL NOT
BE ABLE TO BE A MOVIE STAR!

GOOD BECAUSE YOU'RE JUST
IN TIME FOR AN AUDITION.
YOU'D BETTER GET GOING
AFTER ALL OF THIS TROUBLE!
GOOD LUCK.

Figure 16.6

'Do You Want to Race On The BMX Track?': A Printout
of an Executed Procedure Written as an Interactive Story
(Graphics Done on a Koala Pad); Created
by a Boy in a Grade 6 Class



DO YOU WANT TO RACE ON A BMX
TRACK?
ANSWER YES OR NO

THE COUNTDOWN IS ABOUT TO START.
DO YOU STILL WANT TO RACE?
ANSWER YES OR NO

WHY NOT? IT WILL BE FUN!
YOU ARE NOW GOING TO RACE.
PRINT YES TO GO ON

YOU ARE COMING UP TO A FORK IN
THE TRACK. DO YOU WANT TO TRY TO
JUMP OVER SOME MUD OR OVER A JUMP.
PRINT YES TO JUMP OVER THE MUD OR
PRINT NO TO JUMP OVER THE JUMP.

YOU TRY TO JUMP OVER THE MUD
BUT YOUR BACK TIRE DOSEN'T MAKE
IT SO YOU GET OFF YOUR BIKE AND
PULL IT OUT
PRINT YES IF
YOU WANT TO CHEAT AND GO ACROSS
THE GRASS OR PRINT NO AND TRY TO
PEDAL FAST AND CATCH UP.

YOU GO UP THE JUMP BUT YOU GO TOO
HIGH AND THEN YOU SLANT TO ONE
SIDE AND FALL ON YOUR LEG.
PRINT YES IF YOU WANT TO GO
THROUGHT A TUNNEL AND TRY TO GET
TO FIRST PLACE OR PRINT NO AND
TRY TO CATCH UP FROM BEHIND.

YOU GO THOUGH THE GRASS AND CATCH
UP. PRINT YES TO TAKE THE LEAD
OR NO TO STAY BEHIND.

YOU GO THROUGH THE TUNNEL AND
COME IN FIRST PLACE. PRINT YES
TO KEEP ON PEDALING FAST OR PRINT
NO TO SLOW DOWN

YOU PEDALE YOUR FASTEST BUT YOU
CAN'T CATCH UP. PRINT YES TO
CHEAT AND GO THOUGH THE GRASS
OR PRINT NO AND GO THROUGH A
TUNNLE AND TRY TO GET TO FIRST
PLACE

YOU ARE COMING UP TO THE LAST JUMP
.YOU JUMP OVER IT YOU MAKE PERFECT
LANDING YOU ARE COME INTO THE LAST
STRECH YOU WIN!!!
THE END

WHY DID YOU STAY BEHIND NOW YOU
LOST THE RACE YOU JERK!!!

SLOW DOWN A PERSON PASSES YOU
U TRY TO CATCH UP BUT YOU LOSE
RACE YOU JERK!!!
END

Part Five: Impact on the Curriculum

17. OVERVIEW

18. COMPUTER LITERACY AND LEARNING THE COMPUTER LANGUAGE - LOGO

19. PROBLEM-SOLVING, LOGICAL THINKING, AND TASK CREATION

20. MATHEMATICS

21. ORAL COMMUNICATIONS

22. READING AND LANGUAGE ARTS

23. THE ARTS

24. VALUES AND THE INDIVIDUAL IN SOCIETY

PREAMBLE

The availability of software and how it was being used by teachers and students greatly influenced what aspects of the traditional curriculum was being learned and what new subject matter was introduced. Such factors, as well as others, are explored in detail in Chapter 18. Chapters 19 to 25 offer a composite view of what students learned from their computer-related activities. The findings in Chapters 19 and 21, in addition to researchers' and teachers' observations and students' own statements, are also based on a quiz that asked programming, estimation, and direction questions within the turtle geometry domain. Chapter 19 also explores the validity of paper and pencil tests for assessing knowledge that was acquired primarily in a computer medium. Chapter 20 raises a topic that has received minimal attention in education, namely, that of students creating or defining their own tasks, projects, or problems. Some of the strategies that encouraged or moved students toward such a level of creative expression are explored. Chapter 21 also examines in some detail, estimation strategies that primary students developed, whether or not students become automatically reflective about repetitive acts, and whether knowledge learned in one domain can be readily transferred to another.

17. OVERVIEW

The overall impact of the computer activities on the curriculum varied from "very limited" to "extensive," depending on the general teaching/learning environment both within the classroom and beyond. One of the limiting factors was the teachers' concern for "curriculum overload". Teachers repeatedly expressed concerns over the number of demands that are already placed on the teaching hours and over new demands that are appearing at regular intervals without having any previous topics deleted. In addition, the teachers required time to learn how to operate a computer and to become familiar with the appropriate software before computer activities could become integrated into the curriculum. As one Grade 3 teacher, who had been a mathematics consultant, remarked:

> I don't want to see "computer studies" taught in schools. To me, a computer is a valuable tool and should be used to enhance a program. It should be integrated into programs already in existence but throw out many unnecessary and repetitious areas, e.g. math - long division. No one in his right mind divides a six digit number by a three digit number, but children do so in schools!! Everyone has a calculator. Teach children to use that and we have halved our math curriculum. Use a word processor and we have halved the writing program!! (Dec. 15/83)

Another limiting factor was that teachers were generally very careful not to teach specific curricular topics that would impinge on the "territory" of another teacher in their school. One Grade 7 teacher limited his teaching of Logo and some of its applications, even within the first three months of the study, because of his concern over "What happens next year?" Although some teachers allowed their students to proceed and explore beyond their grade level, they were still very sensitive to the possible impact this had not only on other teachers but also on their students when they entered a more conventional classroom setting again. Interestingly, less concern was expressed when students were learning concepts that, traditionally, belonged to the "secondary" school curriculum. Also, since teachers were still struggling to learn Logo, they were limited in the kind of guidance that they could offer their students. Students who had been in the study for two years, for example, explored little beyond what they had learned during the first year. Although teachers allowed students to take charge of their own learning and actively encouraged them to do so, a sense of unease developed even among those teachers who had the greatest computing expertise when some of their students surpassed them.

> Some of the bright children are now wanting time alone on the machine. Maybe they are looking to escape into it and ignore other things. I am concerned and cautious about this. I am giving them some lone time but they are having to come back and teach the rest of the group. I feel that I must stop them from getting too far ahead, for then, they tend to say that the other kids do not understand. This way they are bringing the group along with them. (Nov. 11/82)

Despite these limitations, unanimous reaction from teachers in this study was amazement at what children, regardless of perceived ability, were capable of learning. Several were also surprised to discover that children did not always build up knowledge from known blocks but quite happily used advanced concepts or ideas which they did not understand, but then worked backwards by trying to understand the various components by manipulating, testing, and observing the corresponding output. A teacher with twenty years of teaching experience in a variety of settings explained the impact this had had on him in the following way:

> I did not realize the degree to which I was telling people how they could learn and what they could learn and when they could do it best - until this year. Having had the opportunity to watch children with Logo, their learning styles and their capability for learning, I now think that the mental input that goes on is quite different than what we have written in our text books. ... I have found that what I have felt necessary in curriculum (and I have been part of many curriculum writing teams) and much of what I have written could be reduced to very short phrases and object lessons. What I did find this year was that I needed to discover how a child really relates to the things around him. How a child attacks a problem when he is faced with a problem-solving experience. (May 19/83)

The factors that released this increased capacity for learning in the computer environment were succinctly stated by one of the intermediate-level teachers, who noted that the computer changes:

> 1) attitudes about learning from passive to active;
>
> 2) attitudes about success and failure;
>
> 3) attitudes about the nature of "truth";
>
> 4) the relationship of the teacher and learner. (Dec. 9/82)

When students were asked what they thought they learned from working with the computers or Logo, they identified five major areas:

1) computer literacy;
2) a computer language, specifically, Logo;
3) problem solving, thinking skills, and cognitive styles;
4) specific subject areas such as mathematics, language arts, geography, music, art, and
(5) affective and social skills.

These areas also matched observations by both teachers and researchers. The extent of learning in any one of these categories depended very much on the relative emphasis teachers placed on each, as well as on other factors that either enhanced or hindered learning. The teacher emerged as a very important influence in shaping a conducive learning enviornment, but teachers, in turn, had to adapt or cope with environmental factors over which they had little control. Some of these factors were:

1) the degree of flexibility in organizing the class's time-table and in dealing with the prescribed curriculum materials; e.g., specialization vs. integration of different subjects; rotary vs. non-rotary classes;
2) the familiarity the teacher had with teaching the routine curriculum for his/her class: e.g., newly assigned teaching responsibilities within the class or school, or familiarity of grade level being taught;
3) the grade level and the number of students and the range of abilities among the students in the class;
4) the number of computers available and whether they were in the classroom or in a computer laboratory;
5) the amount and type of assistance available from volunteers or other support staff;
6) the degree of support that the teacher received from the principal and/or colleagues;
7) the demands placed on teachers by other teachers or administrators inside or outside the school setting; and
8) the type and quality of computer courses available to the teacher.

Some of the critical factors under the control of the teachers that influenced what students learned were:

1) the extent to which the general classroom atmosphere was conducive to exploration and learning by trial and error;
2) the amount of factual information available to students with respect to operating the computer or software, or the availability of suitable reference books;
3) the pool of ideas or possible avenues of exploration available to the students when they had a need for them;

4) the degree to which computer activities were integrated with the traditional curriculum;

5) the social climate that allowed and/or encouraged the sharing of discoveries and ideas; and

6) the extent to which computer activities were shared with others in the school or the community.

Even though important learning in the affective, social, computer literacy, and problem solving areas took place in almost all cases, teachers in general found it more difficult to build an extensive learning experience for all students and to integrate the computer activities with the regular curriculum if they had only one computer in the class, if students had access to a computer laboratory only once a week, and if the teacher had only a limited knowledge of and command over the technology. Guaranteeing equitable access to computers for students while ensuring that the regular curriculum did not suffer, and creating a conducive atmosphere for exploration, were perhaps two of the most difficult problems with which teachers had to deal. Since the emphasis of this study was on the creative use of computers, teachers were compelled to re-examine the meaning of creativity and the appropriate teaching strategies that would allow creativity to find expression. This often led to a reassessment of fundamental teaching philosophies and strategies. The blending, resolution, and interaction of all these various factors influenced what students were able to learn.

Since the teachers were not given any specific direction as to how to use the computers, the manner in which they were used reflected their teaching strengths and their assumptions about the nature of education. For example, since turtle geometry has a definite mathematics flavour, those teachers with a particular interest in mathematics pursued this possibility more than those who did not. Teachers who had a strong interest in language arts emphasized word processing and the use of text and interactive stories within Logo; they were more inclined to view turtle geometry as an alternative learning experience that was not to be evaluated or directed by the teacher. Two intermediate level teachers, who had had programming experience, also treated Logo as a programming language and encouraged their students to learn more and more about the programming features of the language. Less specialization occurred at the primary level and two of the primary teachers who had computers in their classroom were able to utilize and integrate computers in a variety of subject areas. The overall impact on the curriculum presented in this chapter, therefore, is a composite from all these diverse settings and experiences.

18. COMPUTER LITERACY AND LEARNING A COMPUTER LANGUAGE: LOGO

All students from Grade 1 to Grade 8 learned about the basic components of a microcomputer. They learned how to "boot" the computer, how to read from and save onto disks, how to use a text editor or word processor, how to print out stories or pictures, and how to use other educational software. Students who had access to the computers throughout the day learned about "memory" and "workspace" and how to manage the latter and their files. Without clearing the workspace, students would often unintentionally store work that had been done by others before them. They also learned the need to update files and felt the disappointment when they failed to do so:

> Sue and Alan (two intermediate-level students) were upset because the "lighting bolt" they put through the P of 7P last day is gone. On rethinking it they realized they had not updated their file last day. They say they won't make that mistake again. (Nov. 28/83)

They gained a personal familiarity with some of the strengths and limitations of using a computer. The spontaneous and undirected responses that students gave when they were asked what they had learned from working with computers and/or Logo showed a wide range of responses: from "how to use them", to "computers are for everyone, not just kids "(Table 20). Most of all, they learned not to be awed by computers. They acquired a realistic sense of what this technology can and cannot do.

LEARNING A COMPUTER LANGUAGE - LOGO

Logo's capacity to execute commands in the Direct Draw or immediate mode, without pre-imposing a facility or knowledge of programming, gave students as young as six years access to computers. A simplified version was necessary for Kindergarten students since they found it difficult to work the keyboard and to remember spacings and "long" commands. The use of commands in the Direct Draw mode made it easier for students to move gradually into programming, i.e., into using the Logo editor. Initially, there was an eagerness among teachers, even of very young students, to get students to use the Edit mode. This met with mixed success. One Grade 2 teacher, only two months after she first introduced her students to Logo, reported that:

> I was a little worried that they (the children) were not yet developing procedures and were quite content to continue in the draw

Table 20

"What have you learned from working with the computer?"

"What have you learned from Logo?"

Responses Pertaining to Computer Literacy

	Primary	Junior	Intermediate	Total
No. of students sampled	114	84	154	352
Comments		Frequencies		
Computer-specific:				
Logo language	-	15	48	63
How to use them, how they work	15	17	27	59
Programming, writing procedures	5	8	27	40
Word processing, writing stories	7	6	21	34
Lots of different things	8	12	5	25
To type	2	4	8	14
BASIC	-	-	8	8
To print out stories and pictures	4	1	-	5
To play games	2	1	1	4
That there is a text and graphic screen	-	1	2	3
To use Millikan Math	-	-	3	3
To save and retrieve stories from disk	1	1	-	2
Computer-general:				
There is more than one computer system and language	-	1	5	6
Computers are fun	2	-	2	4
Computers aren't smarter than we are	2	-	2	4
Computers aren't as confusing as they look	-	1	3	4
Computers are easy to learn with	-	3	1	4
Computers do what they are told to do	1	3	-	4
Technology is catching up on us	-	1	2	3
To talk to computer	-	1	1	2
Computer can't talk	1	-	-	1
To wash hands & not eat food near them	2	-	-	2
Touch something metal to get the shock off so you won't wreck the computer	1	-	-	1
Not to put a magnet near the computer	1	-	-	1
Grade 4 and adults can cope with computers	-	1	-	1
Computers are for everyone, not just kid	-	-	1	1
Computers are interesting	-	-	1	1
Not to be afraid to break them	-	-	1	1
Nothing much	3	2	3	8
I don't know	7	-	-	7
Total responses	64	79	172	315

> mode, so I tried to move them along a little. I realize now that I should allow them to continue with their experimentation as long as they are progressing with that. (Jan. 14/83)

Grade 1 students found it very difficult to understand the use of the editor for turtle geometry, but quite natural for the use of text. The use of TO and END for entering and leaving the editor were natural ideas for writing a letter to a friend. By printing out the procedure, students were able to retrieve their printed work very easily; and by modifying the print program to eliminate the TO and END, the printout also took on the "natural" form of conventional writing. In Grade 2, more students began to explore procedures, and a Grade 3 teacher reported mid-year that "the children are writing procedures much more readily now". Older students gained greater facility with the use of the Edit mode but they still continued to use the Direct Draw mode during periods of early exploration. One intermediate-level teacher described this process as follows:

> What is neat is students seem to come back and re-write their procedures sometimes three and four times and their final procedure is much different than where they began. The final procedure often includes repeats or variables. Some even use a conditional statement to cause the turtle to stop at a particular location. The initial procedures were very manipulative, like what we often assign Kindergarten children playing with blocks where they place them in a particular order and we see how they group things by colour and shape. Children use that with Logo. They use the ability to maneouvre and manipulate the turtle and place it where they want and then they go back and plan their approach to make a procedure. (Dec. 15/83)

Many students during the early stages of their explorations would type some instructions in the Direct Draw mode and then carefully record them on a sheet of paper. If the result was acceptable, they would proceed by adding a few more instructions. Students thus had to copy previous instructions from the paper and retype them into the computer every time they needed to test their instructions anew. This lengthy process often discouraged students from retyping the finished sequence into a procedure and they were quite happy saving the picture on the disk or making a printout only. With some guidance, however, students could easily learn to use the Logo editor as an electronic notebook:

> Sarah and Iris (two grade three students) were working on the design of a heart. I suggested that they make a procedure for the good part from their notes. They then can try out a few more commands in the direct draw mode. If they make a mistake or don't like what they did, they could easily run the procedure that had all the good parts stored and start over again. When they have it right they then could add those instructions to the program. The girls jumped at the idea and worked very well with it. They went back and forth between the draw mode and the editor quite easily. Their first try was just a line twice

> as long as they had intended. They knew immediately how to fix the procedure. (Feb. 9/83)

The use of the TRACE command also made it easy to examine a procedure step by step. This command greatly facilitated any problem-solving that may have been necessary by allowing students to analyze a procedure after each instruction was executed.

One of the main objectives of the designers of Logo was to create a computer language that emulated the natural thinking processes, in particular of children. Teaching turtle geometry was found to be easy since teachers could indeed invoke their students' own body movements to demonstrate turns and movements on the computer. One Grade 1 teacher was able to obtain plastic inflatable turtles which the students held in front of them and, as students moved on appropriately marked cardboard circles while other students called out various sized turns, the turtle, pointing away from the child's body, moved with them. She found this to be a useful exercise which was enjoyed by her students. Even an intermediate-level teacher encouraged his students to use their hands to follow through a sequence of "turtle" commands before they touched their keyboard. He reported that:

> Sometimes I even see kids standing at the side of the classroom turning one way, then another, moving their hand, almost talking to themselves. Anyone else would say I just had a strange room. But I know how what they are doing and when they go to the computer, often they have very accurate answers in a very short time. They walk through their problems. This is good learning step; to walk through a problem one step at a time; to see it from beginning to end. (Dec. 15/83)

Logo also had some well chosen words or primitives that made it easy to invoke and develop the students' use and knowledge of the language. For example:

> Leonard and David (two grade three students) were making an airplane. They drew a gun on the bottom of the aircraft and then concentrated on making bullets appear to come from the guns. They were doing a pen up, forward, pen down routine over and over again. I suggested that they already knew a Logo word that can make something happen over and over again. "REPEAT!" They tried it. "Ever neat!" they exclaimed when they saw it. (Jan. 17/83)

Some concepts that traditionally were considered advanced were quite easily handled by younger students. Programming with variables became natural for Grade 3 students. Early conceptual difficulties could easily be overcome through direct demonstrations. For example:

> Cameron and Jennie (two grade five students) were working with variables. They didn't understand that a variable allowed them to control the size of the procedure they were working with from outside the procedure. They were changing the value inside the procedure.

> I suggested leaving the procedure the way it was for the moment, and typing in different inputs after the name of the procedure to see what happened. Once they saw the result, they understood. Cameron said next time he would go back and make some of his old procedures variables. (Feb. 23/83)

Using procedures as building blocks within larger procedures was also easily understood by students from Grade 2 up. However, planning an activity in terms of modular components did not come automatically without assistance from the teacher. Students in a junior-level class who did not receive such assistance and encouragement still wrote very long procedures that showed very little structure, even after working with Logo for two years. For example, one of the researchers noted that:

> Many of the procedures were very long. Often the children worked in the draw mode copying down the directions on paper and then typing these in to make procedures. They typed it exactly as it was written, not bothering to do the addition or any refining at all. This applied to both students who are new to Logo and those who were in the study last year. (Dec. 1/83)

Using procedures within procedures made it relatively easy to introduce the concept of recursion which, on occasion, students were able to discover by themselves. The earliest such discovery was by one Grade 3 student. An intermediate-level student came upon recursion the following way:

> Brian has procedures SUN and SUN1. He wanted to know how to get them to "work together". I reminded him that one can put procedures inside procedures, etc., but something happened and he called me back looking very alarmed. It wouldn't stop! He had used the name SUN1 for the program and the last line of his program was SUN1. He wasn't aware of recursion and thought his discovery was really neat. It will be interesting to see how he uses it. (Nov. 16/83)

Conditional statements began to appear in one of the junior-level grades but were used more frequently by students at the intermediate level.

The graphic output of students' various computer activities showed great variety in programming strategies. One intermediate level teacher took advantage of this diversity when one of the researchers showed his students a collage of computer work done by primary and junior level students. He directed his students to look at the procedures quite carefully and to see if the procedures could have been written differently or improved upon. The students enjoyed seeing the work of others. Reactions included:

> The pictures are impressive, but when you look at the program you see it's really easy. It's just all FD, BK, LT, and RT.

> Some programs could be shortened.
>
> Could have simplified some of it by using REPEAT and sub-procedures.
>
> When they name procedures they don't always name them names that tell what the program does.
>
> Naming of procedures is not so important.

In order to obtain a broader and "objective" measure of how much individual students had learned about Logo, students were given a quiz on turtle geometry at the end of each year. During the first year, the quiz for primary grade students had two parts: one was administered on paper and the other at the computer with a researcher in attendance to read or clarify questions. (Note: Part I was not administered to students of site 3a because of scheduling difficulties.) During the second year, no quiz was administered to the Grade 1 students (site 3b) since for the three months prior to the date of "post-testing", the students' activities on the computer had been sporadic as their regular teacher was on leave. At the end of the second year, the Grade 3 students were given the identical quiz and under identical conditions as the junior- and intermediate-level students. The quiz for junior/intermediate students was identical (except for the addition of one question on variable procedures in the second year) for the two years; a researcher was in attendance to deal with possible ambiguities in questions. The paper and pencil portion of the primary quiz asked students to write commands and sketch what those commands would draw on the screen (the specific questions are presented in Table 21). A copy of the junior/intermediate quiz is included as Figures 18.1 and 18.2, and the marking scheme used to determine the scores for this quiz is presented in Table 22.

The level of understanding of the concepts tested and the ability to predict the outcome of a series of commands or instructions varied greatly within a class and across grades. The results by primary-level students showed that 41% of the Grade 1 class, 75% of the Grade 2 class, and 100% of the Grade 3 class were able to write down some turtle commands on a sheet of paper. However, when students were asked whether they could sketch what the turtle would draw with these commands, only 6% of Grade 1 students, 25% of Grade 2 students, and 75% of the Grade 3 students were able to do so correctly. Most of the commands that they gave were meant to produce either a circle or a square although a few attempted to give instructions for a house, a triangle, an octagon, or a kite. When students were asked "Can you fill in the blanks of REPEAT ___ [FD ___ LT ___]?", 48% of the Grade 1 students, 75% from Grade 2, and 100% from Grade 3 were able to respond to the question. Of these, however, only 6% of the Grade 1 students, 10% from Grade 2, and 80% from Grade 3 were also able to sketch what the given instructions would draw on the computer (Table 21). Again, the most common shapes that were given correctly were the circle and the square. There were unsuccessful attempts to draw triangles, a star, a mountain, and stairs. A similar pattern was noted when students were asked "Can you write a procedure?" and "Do you know what it will draw?": none of the Grade 1, 55% of the Grade 2, and 100% of the Grade 3 students were able to write a procedure, but only 10% and 75%, respectively, were also able to make a correspondingly correct sketch. The predominant shapes attempted and drawn correctly were again the square and the circle, although there was much greater variety among the Grade 3 students this time. The correct procedures and sketches included a rectangle, an octagon, stars, a house, a design, a tree, a flower, and a face. One of the procedures given used a variable and another used subprocedures. Although age appeared to be a definite factor in what students were able to do, some of the differences were also due to the time students spent with Logo. The Grade 1 students had at most seven hours hands-on time with Logo, the Grade 2 students had at most approximately 11 hours which were spread out over a six months period. The Grade 3 students had approximately forty hours spread over an eight month period but with the greatest exposure to Logo during the three months before the quiz was administered.

The responses obtained from the junior- and intermediate-level students at the end of each year and from the Grade 3 students at the end of the second year, revealed that age was not a determining factor in how well students coped with some of the more complex programming questions (Figure 18.3). The nature of the teaching/learning environment became the predominant factor that influenced students' performance on the quiz. For example, the average score on the quiz for the Grade 3 students (site 5b) in 1983-84 was 47%, which was only exceeded by the Grade 6/7 students (site 8a) in year 1982/83, and by Grade 7 students (site 8ab) who had been in the study for two years. The average scores from students in the other grades, which included a Grade 8 class, were lower than those obtained by students of the Grade 3 class. Details of the item-by-item analysis may be found in the set of Tables 36, 37, 38, and 39 in Appendix A. A review of these tables shows that Grade 3 students held their own or even excelled over students in Grade 7 on questions that dealt with concepts of single or multiple variables. Students from the Grade 3 class fell below the performance of the other classes only on writing a procedure for a rectangle using variables. However, they were able to identify the meaning of the variables in the procedure:

```
TO WIBBLE :N :L :A
REPEAT :N [FD :L RT :A]
END
```

Of the Grade 3 students, 48% could correctly sketch WIBBLE 6 50 60, and 76% could give the values of :N, :L, and :A for a square.

Table 21

Responses to the Following Questions on the Logo Quiz for Primary Level Students

1. "Can you write down some turtle commands (on paper)?"
   and "Can you sketch what the turtle would draw?"
2. "Can you fill in the blanks for REPEAT __ [FD __ LT __]?"
3. "Can you write a procedure?" "Do you know what it will draw?"

Site	3a	4a	5a
Grade	1	2	3
		Percentages	
Question 1			
attempts	41	75	100
sketch concurs with commands	6	25	75
Question 2			
attempts	48	75	100
sketch concurs with commands	0	10	80
Question 3			
procedure format correct	0	55	100
procedure format incorrect	0	15	0
sketch correct	0	10	75
no attempts	100	30	0

Table 22

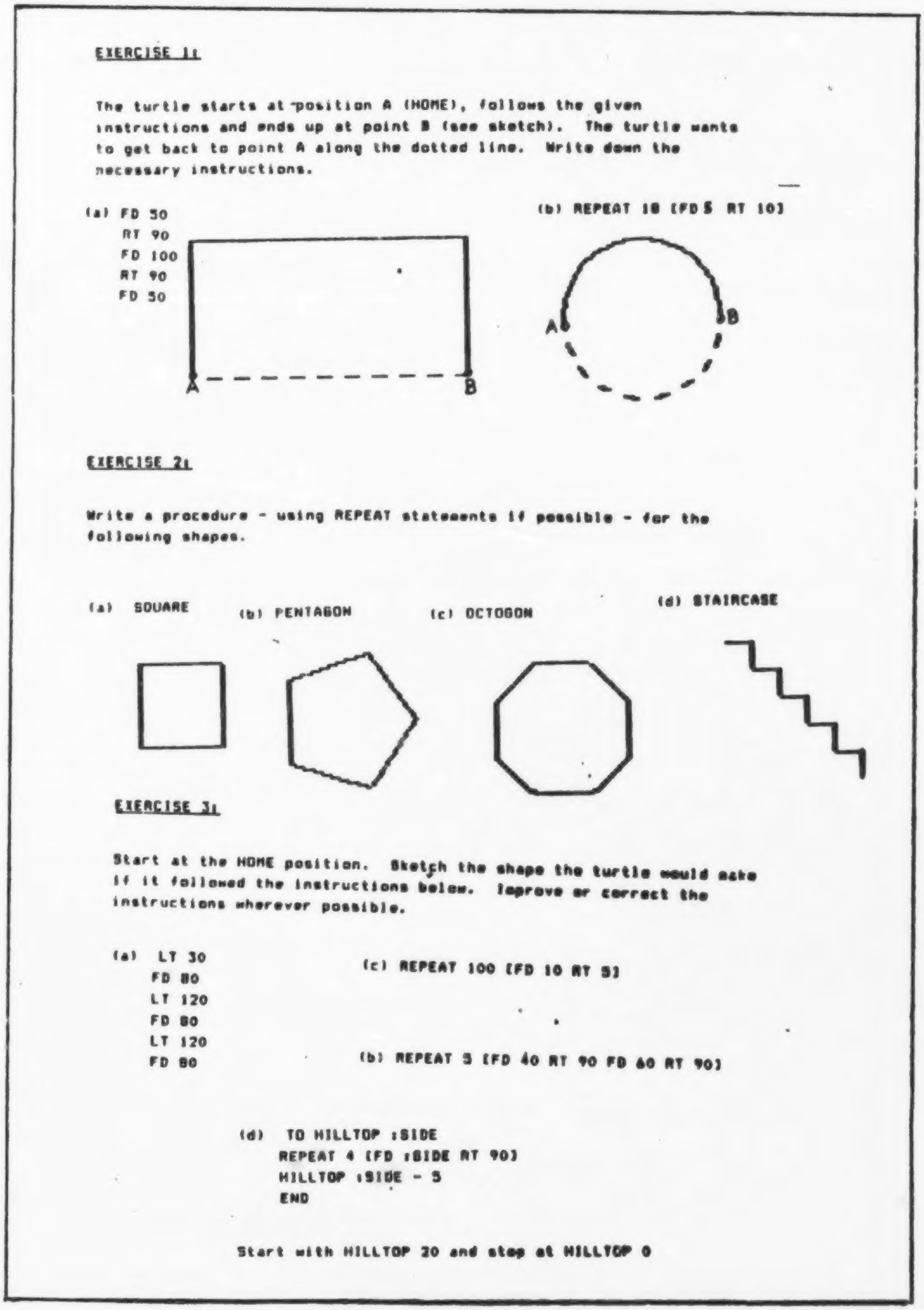
Marking Scheme for the Junior/Intermediate Level Logo Quiz

	Total number marks possible		Total number marks possible		Total number marks possible
Ex. 1a		Ex. 2a-2d			
correct	2	repeat correct	1	Ex. 3a - d	
Ex. 1b		pattern correct	1	sketch correct	1
correct	2	format correct	1	position correct	1
		all correct	1	improvement correct	1
				all correct	1
Ex. 4		Ex. 5		Ex. 6a	
format correct	1	attempting question	1	correct	2
repeat correct	1	top level procedure	1	Ex. 6b	
variable correct	1	some procedures	1	1 point each variable	3
sketch correct	1	all correct	1	all correct	1

Figure 18.1

Logo Quiz for Junior-and Intermediate-Level Students:

Exercises 1, 2 and 3



EXERCISE 1:

The turtle starts at position A (HOME), follows the given instructions and ends up at point B (see sketch). The turtle wants to get back to point A along the dotted line. Write down the necessary instructions.

(a) FD 50
RT 90
FD 100
RT 90
FD 50

(b) REPEAT 18 [FD 5 RT 10]

EXERCISE 2:

Write a procedure - using REPEAT statements if possible - for the following shapes.

(a) SQUARE
(b) PENTAGON
(c) OCTOGON
(d) STAIRCASE

EXERCISE 3:

Start at the HOME position. Sketch the shape the turtle would make if it followed the instructions below. Improve or correct the instructions wherever possible.

(a) LT 30
FD 80
LT 120
FD 80
LT 120
FD 80

(c) REPEAT 100 [FD 10 RT 5]

(b) REPEAT 5 [FD 40 RT 90 FD 60 RT 90]

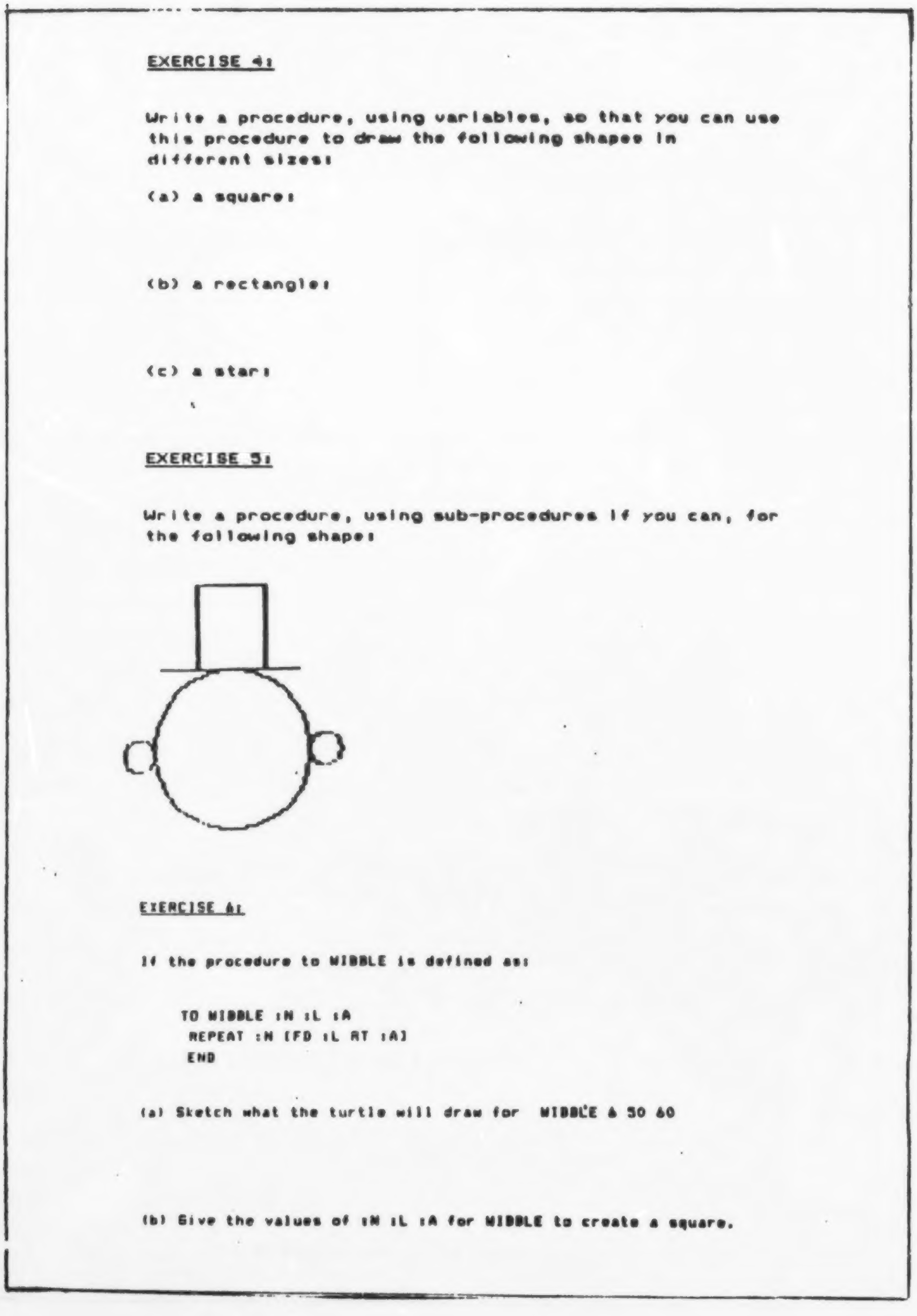
(d) TO HILLTOP :SIDE
REPEAT 4 [FD :SIDE RT 90]
HILLTOP :SIDE - 5
END

Start with HILLTOP 20 and stop at HILLTOP 0

Figure 18.2

Logo Quiz for Junior-and Intermediate-Level Students:

Exercises 4, 5, and 6



EXERCISE 4:

Write a procedure, using variables, so that you can use this procedure to draw the following shapes in different sizes:

(a) a square:

(b) a rectangle:

(c) a star:

EXERCISE 5:

Write a procedure, using sub-procedures if you can, for the following shape:

EXERCISE 6:

If the procedure to WIBBLE is defined as:

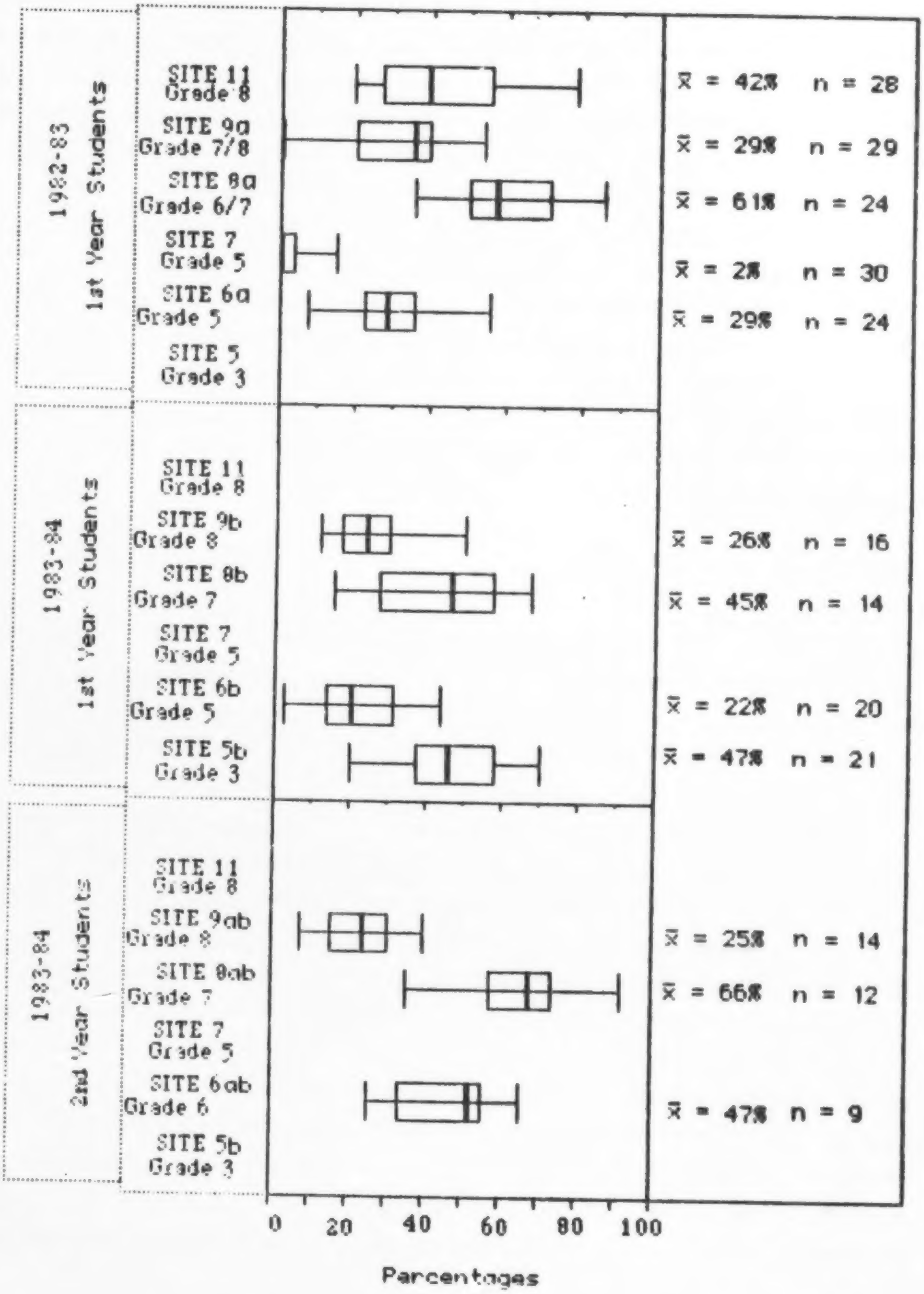
```
    TO WIBBLE :N :L :A
     REPEAT :N [FD :L RT :A]
     END
```

(a) Sketch what the turtle will draw for WIBBLE 6 50 60

(b) Give the values of :N :L :A for WIBBLE to create a square.

Figure 18.3

Scores Obtained by Students on the Junior/Intermediate Level Logo Quiz Given at the End of Each Year



Also striking among the Grade 3 students was their general level of confidence. All students had been assured that they were not expected to be able to answer all of the questions but that they should try to attempt the questions if at all possible. The Grade 3 students had the lowest rate of "no attempts". It was somewhat surprising that many students could not execute the instructions in question 1a and 1b, and there were still students who did not know the instructions for a square. The majority of students were unable to give the correct "pattern" for a pentagon and an octagon (see questions 2b and 2c on Table 37). (A correct pattern usually indicated a correct numeric value for the appropriate angle since students seldom had difficulties with the distance command FD.) Identifying the pattern for the "staircase" was again not easy for many students, although several made "only" a directional error in that the steps ascended to the right instead of the left. Only a very small number of students from all grades were able to sketch question 3d which involved recursion. Approximately 60% of the students from Grade 3, Grade 5, and Grade 7 were able to write a variable procedure for a square, and approximately 50% of the Grade 7 students were also able to draw a variable procedure for a rectangle correctly. 78% of Grade 5 students, 70% of Grade 7 students and also 48% of the Grade 3 students were able to draw a correct sketch for WIBBLE 6 50 60 (question 6). No attempt was made to test the students' facility with conditional or list properties of Logo although, by implication, there was a hint of recursion in question 3d.

In order to give meaning to the diverse results on the Logo quiz among the different sites, it is necessary to identify some salient features of the teaching/learning environment operative at each site. The strong performance of the Grade 3 students on the quiz seems likely to have been due to a close correspondence between their computer and classroom activities. The teacher was committed to furthering her students' understanding of Logo as a computer language as well as a means of exploring specific mathematical ideas. To help achieve this, she integrated class lessons on geometric shapes, mapping, and angles with concepts in turtle geometry. She often used examples of students' work to demonstrate a particular concept or idea. Recently taught concepts or "formulae" as well as suggestions for using, extending, or modifying these concepts were readily available to students in the form of cards placed by the computer. Students were shown examples of using procedures within procedures, and were encouraged and given time to explore their own ideas. Discoveries and questions that were generated from computer activities often became a focus for class discussions and lessons. Student access to computers was high: each pair of students spent approximately 100 minutes per week on the computer. Some of this time was spent with a word processor but the greater proportion was spent on turtle geometry. The teacher considered it very important that she had a relatively small class (23 students), and regular parent volunteers to assist her in attending to routine tasks. This freed her to observe and interact with students at the computer on a regular basis, although still not as much as she would have liked.

The teacher of site 8a (year 1982/83) also provided strong leadership. He allowed his students to explore a great deal but gave formal lessons on writing procedures, the use of variables, and on conditional statements. He gave exercises that emphasized the use of "top-down" procedures (using procedures within procedures). In addition, he presented many challenges that encouraged his students to reinforce or expand on a lesson. However, he did not formally connect turtle geometry with the mathematics curriculum. His students had access to manuals, and group sharing sessions were arranged and encouraged. During the second half of the year, two computers were available throughout the day and each pair of students had at least 100 minutes per week at the computer. Students were encouraged to explore the text and list capabilities of Logo, and minimal time was spent on the Bank Street Writer. Since the class was a split Grade 6/7 and since the Grade 7 students attended classes on specific subjects away from the homeroom for part of the day, the teacher was able to observe and interact with a smaller group of students during that time. This made it possible to observe students and to offer them occasional informal approval, guidance or direction.

The teacher of site 6a (year 1982/83), on the other hand, viewed turtle geometry as an alternative learning experience which was free of teacher's judgment or evaluation and almost free of teacher input. Although she was extremely interested in computers, she felt somewhat overwhelmed by them. She considered herself adequate in mathematics but her strong interest was in language development - especially writing. Her students spent almost equal time between turtle geometry and the Bank Street Writer. Students received a few class lessons on some programming features of turtle geometry, and further assistance was given through cards at the computer that aided in the exploration of ideas and offered "new" primitives or programming features. A great deal of sharing was encouraged. Assignments in turtle geometry did not necessarily stress mathematical concepts, but took the form of "make a drawing or design that expresses how you felt on our last field trip". She saw the "Logo experience" as an opportunity to allow students to take charge of their own learning, to become adept at problem solving, and to bridge the social barriers among some of the students within the school. Instead of extending her students' knowledge of Logo, she offered them the opportunity to share what they had learned with Grade 4 and Kindergarten students. She spent time with her students analyzing the role of the teacher and possible teaching strategies for young children, and also engaged her students in simplifying Logo for the Kindergarten students. This led to examining the relevancy or "naturalness" of every "primitive" they defined so that they could be logically understood by very young children. All students kept a computer journal in which they were required to report their computer activities for the week in some detail. The teacher also chose the medium of the computer journal to "stay in touch" with students' problems and questions that could not be attended to immediately. She encouraged imaginative expression by getting students to adopt the "screen turtle" by giving it their own name. "Appledumpling" was their chosen name and it became the focus for a variety of art activities, for adventure stories, and for a class play. The students had access to one computer throughout the day during the first three months, and to two computers in the second half of the year. Each pair of students spent approximately 2 - 3 hours per week on the computer. The teacher encouraged group discussions and demonstration sessions where students could present their work or their problems and solicit reactions from other students.

The teacher of site 7a became frustrated by having access to the computer resource room only once a week and by the confusion that was generated by 32 students having to share 12 computers during a 40 minute period. He gave up on turtle geometry after three months but later returned to work on word processing and other educational software. The teacher of site 9a (year 1982/83) had one computer for 32 students. All of his students were on a fixed rotary time-schedule which gave little flexibility in scheduling and only limited time to teach even the basic programming features of turtle geometry. With the exception of two specific assignments, students were free to use the computer when their regular classwork was done and when they were in their homeroom. Some students hardly ever used the computers; others used it as much as possible. The teacher of site 11a had access to a computer resource room for a 40-minute period every day and, after some initial skepticism about Logo, began to spend almost all of his computer time on turtle geometry towards the end of the year. He viewed turtle geometry as a means of exploring programming as well as mathematical concepts. He gave a great deal of direction by means of class lessons and assignments or challenges. His students explored other educational software such as Milliken Math and, to a limited extent, the Bank Street Writer, and Magic Window for word processing.

Additional evidence that the teaching/learning environment is extremely critical in what students were able to learn came from a comparison of students' performance on the Logo quiz from sites that had the same teachers during both years of the study: sites 6a (year 1982/83) and 6b (year 1983/84), sites 8a (year 1982/83) and 8b (year 1983/84), and sites 9a (1982/83) and 9b (1983/84). Even though the teachers remained constant, the number of computers in the classroom, the composition of the classrooms, and the teachers' teaching responsibilities were significantly different in the two years. The number of computers in sites 6 and 8 were increased from two to four and in site 9 from one to two. Site 6b had four APPLE II+'s and two printers which functioned well as a unit. Site 8b, however, had two APPLE II+'s, one APPLE 2e, one ATARI, and two printers connected to the APPLE II+ machines; a COMMODORE 64 was added later in the year. The mix of computers, the fact that at least one computer had some technical problems, and the lack of printers for two of the models made it very difficult to treat the five computers as a unit for scheduling, trouble shooting, or for completing programs or activities that extended beyond one computer period. Activities that were started on one model could not be continued on another, and locating the appropriately formatted disks led to confusion - with drastic consequences at times: one of the master language disks was inadvertently ruined when it was used to boot the wrong machine. Frustration arose among students because of the minor programming idiosyncracies between the various Logo versions which was aggravated by the fact that their total computer time was rather limited. Students began to favour certain familiar models over others and eventually refused to use their computer time if it was not on their favourite model. This class effectively had therefore three instead of five computers. (The fact that three different models of computers in one of the Grade 1 classes did not create confusion, may have been due to the fact that each computer had different accessing devices and were used for distinctly different purposes: the Apple II+ had a disk drive and was used for turtle geometry, the TI 99/4A had a cartridge deck and was used for Logo sprites, and the PET had a tape recorder and was used for educational games). Site 9b had two APPLE II+ machines but still only one printer.

The composition of the classrooms changed also. Whereas site 6a was a straight Grade 5 class, site 6b was a Grade 5 class within a 5/6 split. Site 8a was a split 6/7 class, site 8b was a Grade 7 class that was entirely on a rotary school time-table. Site 9a was a split 7/8 class and site 9b was a Grade 8 class. All of these classes had students that were with the teacher the previous year. The teacher of site 6b had not taught a Grade 6 class for a long time and she felt she needed time to familiarize herself with this curriculum. She also felt somewhat ill at ease coping with pre-adolescents, even though she had had these older students the year before. The teacher of site 8b was given the additional responsibility of teaching language arts to the entire intermediate-level grades in the school - a subject which he had not taught at this grade level before. The teacher's responsibilities in site 9b did not change as drastically, but since all of his students were approaching high-school the following year, he became even more concerned about attending to the regular curricular needs. He therefore spent even less time on Logo than the previous year. In addition, these teachers became heavily involved in committee work with respect to computers inside and outside their school. Since so much of the energy of these teachers was diverted to dealing with new classroom conditions and with outside commitments, they had little time to explore how they could further utilize Logo in their classrooms. They ended up relying very heavily on the "experienced" students to teach the new ones, and the "experienced" students received very little input to further their own learning of Logo. The teachers of site 6b and 8b found it more difficult to set aside class time for group discussions which formed such an important part of their classroom life the previous year, although students were still encouraged to share informally.

All these difficulties were reflected in how well students did on the Logo quiz. The average and the range of scores obtained by first year students in 1983/84 were consistently lower in all three sites than those obtained by first year students in 1982/83 (Figure 18.3). Also, the proportion of correct answers by the two-year students was consistently lower in 1983/84 than those obtained by the same students in 1982/83. Many second year students expressed concern over the fact that they weren't learning anything new.

Since the Logo quiz was intended to obtain an "objective" measure of what students learned, some of the concerns raised by the junior- and intermediate-level students about the validity of a paper and pencil test as a measure of their "learning" warrant close examination. Most students had experienced Logo in a non-judgemental manner and several students became very nervous when they were presented with a paper that reminded them of a test. Some students felt that they knew or had known some of the items at one time, but since they had not worked with them for a while, they couldn't remember them. This was partially confirmed by a review of the responses by students who were in the study for two years. Except for the three girls in site 6ab, all other students who answered the quiz in the second year had lost points for items which they had answered correctly - especially by paying greater attention to details - the previous year. The drop in the final score due to such items was from 2% to 18% with a mode of approximately 6%.

These preceding features are common to any test situation. However, students also raised issues that challenged the validity of evaluating knowledge that had been acquired and used in one medium by means of a different medium. For example, students commented:

> Junior:
>
> They told us to do things I knew how to do but it seemed confusing on paper. (April/83)
>
> There is no computer in front of you so you can't really see what you are doing. (April/83)
>
> I was used to working on the computer not on paper. I had to guess where the turtle will be. You get confused just guessing. (April/83)
>
> I found it hard because I had to pretend my pencil was the turtle and I had to estimate where the turtle was going to go. (April/83)
>
> Intermediate:
>
> All year we have learned in a different fashion and now you ask us to think with paper. You have to prepare us for paper and pencil. (April/83)
>
> I forgot where the turtle was because I didn't see it's prompt. (April/83)
>
> It's difficult without doing it on the computer. (April/84)

The validity of the results obtained from a paper and pencil medium may be even more questionable for the Grade 1 and Grade 2 students. Evidence from classroom observations certainly indicate that some of the Grade 1 students were beginning to develop a good facility with manipulating certain aspects of Logo on the computer:

> [Grade 1] Ann, after playing with the stairs formula (given by the teacher) decided to make them longer. She used a larger number for REPEAT and when she saw a pattern forming between the two wrapped lines decided to do more. She repeated it 300 times and filled the screen with patterns of squares. She was very excited. (March 17/83)
>
> [Grade 1] Elwood, who had been given the instructions for a circle at home by his father, used different values for FD in circle left and right to make "eyeglasses with eyeballs". He said "Oh, oh" when he used too big a number so that the circle went off the screen. He was not dismayed by this because he felt confident that he could do it again, but, this time, with a smaller number. He did it too! (March 17/83)
>
> [Grade 1] Alec copied commands from a card that had REPEAT __ [FD __ RT __] on it but he typed only REPEAT FD RT. It didn't work.

> He realized that he had forgotten the numbers and retyped REPEAT 100[FD 7 RT 8] which drew a circle. Alec repeated the procedure and got another circle.
>
> [Grade 2] Jimmy showed me his SUPERMAN1 procedure:
>
> ```
> TO SUPERMAN1
> REPEAT 49[FD 49 RT 49]
> END
> ```
>
> He could not predict for me what would happen if he changed the FD number or the RT number. However, he did know how to find out and without hesitation changed the angle to 100 and ran the program again. When he saw that this made the centre circle smaller he decided to make it even smaller. He typed in 200 for the angle and was very pleased and surprized to get a star. His next move was to change the angle to RT 500. (May 12/83)

Some of the comments students made were particularly relevant to questions that required sketching. Students did not seem comfortable with the notion of "sketching" and were very concerned about being precise. Several students wanted to use a protractor and ruler. Students' comments included:

> [Junior] It was hard to draw an angle because in the computer the turtle knows exactly where right 10 is or left 70 is and it is hard to draw it on a piece of paper. (April/83)
>
> [Junior] It is hard to decide what the turtle will do without the computer. When you are wrong on paper it stays wrong. (April/83)
>
> [Junior] When you read some of the stuff you can picture it in your mind because you are used to thinking. And the hard part about it (doing the questions on quiz) is that to get a picture perfect you have got to have a computer because that is what you are used to thinking with. (April/83)
>
> [Intermediate] Getting the angles right is hard without a protractor and on the computer you can always go back and change your program. (April/84)
>
> [Intermediate] I found that working on paper is a lot different than working on the computer. The reason why, is because on the computer you can see if you are right or wrong. On paper you have to guess. All you have is a 50:50 chance of being right. (April/84)
>
> [Intermediate] The computer is easier to use because you can try and if its wrong erase it. (April/84)

There may be something inherent in the technology that allowed students not to be reflective about certain things. For example:

> Frank (a grade three student) is creating a space screen. One planet is created by a circle that goes around 360 degrees twice. I asked him why it went around twice, and he answered rather off-handedly as he continued to type that he could just cut the repeats in half, but it doesn't matter if it goes around twice. (April 19/84)

Speed of execution, if done by the computer, was obviously of no concern to this student. There were many other situations where students allowed the computer to do "extra" work as long as the desired result or product was achieved. Some students also relied on the built-in knowledge of the computer and used it as a tool without feeling any need to acquire that knowledge themselves. For example, a junior-level student, in response to the Logo quiz, commented:

> I had trouble with thinking how many degrees the turtle would turn and how far it would go because I was so used to the computer telling me how far it would go but now your telling me to tell you how far it would go thats why it was so hard doing the test. (April/83)

Although students commented throughout the year that working on the computer was challenging and it made them think hard, many students also indicated that the paper and pencil test was hard because they had to "think more this way". It could well be that the "hard thinking" in these two cases referred to different aspects of the activities involved. One possible inference might be that some students viewed a given set of commands for a square, triangle, etc., as "tools" that were to be used but not reflected upon. The hard thinking may then have referred to the process in which such tools were embedded. Such a process may deal with the creation of a task, with defining a problem to be worked on, or it may deal with the use of the given tools in various creative combinations, the analysis of strategies in approaching a given problem or task, or it may deal with the analysis of a "mistake" encountered in the process. For these students, the questions on the Logo quiz tended to focus on the knowledge or understanding of the tools used. There were some students who very quickly and instinctively examined both the tools and the process. There was strong evidence, however - based on the results on the Logo quiz and on classroom observations - that the best learning or teaching strategy is one that offered students a balanced mixture of instruction about basic "tools", reflective challenges or questions, and ample time for undirected exploration. A significantly larger proportion of students gained greater facility with Logo and its underlying programming and mathematical concept and tools under those circumstances. Students' own assessment as to what they have learned from working with Logo is presented in Table 23.

Table 23

"What have you learned from working with a computer?"

"What have you learned from working with Logo?"

Responses pertaining to Logo

	Primary	Junior	Inter-mediate	Total
No. of students sampled	114	84	154	352
Comments		Frequencies		
Logo-specific:				
To draw graphics, pictures, shapes	29	25	36	90
How to program, write procedures	3	14	20	37
What Logo is and how it works	-	10	17	27
Lots of things	5	6	3	14
How to dump pictures or stories on printer	-	8	1	9
How to make and save things	-	4	3	7
Make quizes using text	1	1	4	6
Make songs	5	-	1	6
Logo Text	-	3	1	4
Make designs with or without variables	-	-	3	3
Make sprites	2	-	-	2
Easier to make pictures; drawing is really fun on the computer	1	1	-	2
How to make things in colour	-	1	-	1
Some programs of pictures are harder than others	-	1	-	1
I have learned to use but not to understand it	-	-	1	1
Logo-general:				
Another computer language	-	-	7	7
Logo is good for young people	-	4	3	7
Logo is challenging	-	2	2	4
Logo is fun learning	1	1	1	3
Logo is easier than Basic	-	1	2	3
Logo is an easy language to learn	-	-	1	1
Don't know	5	2	2	9
Nothing	-	3	3	6
Total responses	52	87	111	250

19. PROBLEM SOLVING, LOGICAL THINKING, AND TASK CREATION

Tasks that encourage the development of problem solving skills and strategies vary from being very specific to being extremely open-ended. How much flexibility a student has in developing such skills or strategies depends on the freedom or the number of choices inherent in the set task. A problem such as "How much is 3+9?" is very specific and directed; however, a problem such as "How many pairs of numbers add up to 12?" is still directed but less specific. "Make a design, using several geometric shapes", "Draw a picture of a tree", "Program something on the computer to represent your feelings and impressions of your recent field trip", "You are free to explore whatever you wish", and "Try something and see what happens" are tasks that are increasingly open-ended, and thus place more demands on students with respect to setting priorities and exploring strategies. The computer, coupled with appropriate software, allowed a teacher or student to exercise the full range of such tasks within a mathematical, linguistic, artistic, and social context. Teachers responded frequently and at length about turtle geometry's impact on problem-solving, for example:

> [Kindergarten] To make the turtle go where they want it to go requires problem solving that they don't require in other areas during their day. (May 12/83)
>
> [Grade 1] The teacher can ask leading questions or present challenges (i.e., try to do this ...) which leaves the child with a problem to ponder. (May 12/83)
>
> [Grade 2] The idea of starting something very simple and building on it to create something more complex is best described by Logo. (May 12/83)
>
> [Grade 3] Logo is invaluable in explaining how to solve a problem. What are you trying to make? Are all the steps necessary to do this? Cause and effect and logical reasoning are easily explained. (April 15/83)
>
> [Grade 3] Ingrid used her twenty minutes on Friday to type in all the polygon procedures and save them on her new disk. 'Then I'll have them.' When I walked in after duty she said 'watch'. Then typed in 'STAR'. 'I used a procedure, now I don't have to save the picture, just the procedure - much better.' Words fail me. What do you say to an eight year old who has thought this all out for herself. (Jan. 15/84)

> [Intermediate] Kevin & Roger brought their log books to the computer. They have a lovely drawing of E.T. with Logo commands for the first part of its execution. They typed it in to try it out. They called in their class advisor to help them with estimating an angle. Their tack seems to be to walk the turtle a bit at a time and when they get it right add it to the procedure. (Oct. 23/83)
>
> [Intermediate] The visual representation is in front of the student he sees whether he is right or wrong. By intuition, he makes changes. (Dec. 15/83)

In the above examples, problem solving was exercised in achieving a set goal. With an increase in the complexity of the task, an increasing number of decision points occurred at which strategies or specific skills had to be used. It was possible for students to engage in reflective action throughout the execution of a task or exploration. Alternatively, if no specific goal had to be achieved or if it was possible to use "formulae" obtained from either the teacher or peers, it was possible to engage in an activity with little conscious analysis. At times, some students also found it tempting to let the computer do some of the thinking. This became particularly evident when students were asked to react to the quiz on turtle geometry. For example, a junior-level student remarked that:

> I think the REPEAT exercises were pretty difficult because you have to think about it when if you were on the computer you could just put down what it says and wait till it does it on the screen. (April/83)

However, intense exploration, analysis, and discussion took place when a mistake or "bug" occurred. For example, one of the researchers observed two Grade 3 students who were trying to use a variable input in the procedure for drawing a square, and recorded the following:

> They started with
>
> ```
> TO SQUARE :SIZE
> REPEAT 1[RT 90 FD :SIZE]
> ```
>
> obtaining a straight line when they substituted a value of the variable 'SIZE'. Their next try was
>
> ```
> REPEAT 1[RT 90 FD :SIZE RT 90]
> ```
>
> "See, it turns," Kelly said enthusiastically when Brandy looked disappointed when a straight line appeared again. She quickly typed in:
>
> ```
> REPEAT 4[RT 90 FD :SIZE RT 90]
> ```
>
> "Oh, Oh!" They got a straight line again. They used motions with their hands to "walk" their procedure through the various steps and came up with the following solution.
>
> ```
> REPEAT 4[RT 90 FD :SIZE RT 90 FD :SIZE]
> ```

> They were delighted and did not mind that the square was drawn twice. It worked beautifully as far as they were concerned. Now they went on to use this square to make a star. They confided that they had done the same thing yesterday but had forgotten to save it. (Jan. 17/84)

A teacher from a junior/intermediate class reported that:

> Students, experienced in Logo, tend towards a pragmatic approach; they find out what works - then work backwards to find out why. I always tried to teach principles first and then their application, but if that's the way students think, I go along with it. (April/83)

Within this medium, there is little burden on the teacher to make the problem meaningful for the student. Whether the student chose his or her own task or whether the task was set by the teacher, the problem solving very quickly became personalized.

> [Learning Disability Class] First of all the kids love the term DEBUGGING - it sounds better than "figuring out" or "correcting" ... I have never seen students not mind the correcting process to this degree. It's just another challenge for them to go back and figure out how to debug. There are no complaints when an error occurs - they immediately seek to correct it. It is so important that these children learn to be able to spot their errors and be able to reason out alternatives. (June 29/83)

> [Junior] When a child has to consider why a program needs debugging, how to debug, what to anticipate when this or that is done, he is able to develop problem solving skills more readily because he sees the tangible results of his thinking immediately. He can rethink his program step by step and find out where he needs to adjust his thinking. (May 15/83)

> [Intermediate] Karl is using three variables in a star program. He works without hesitation - just keeps trying things until he gets it the way he wants it. He doesn't waste any time deliberating about whether or not his next move is right. (Oct. 23/83)

> [Emotional Adjustment Class] Attention span seems about twice that in any other strategy, therefore, problem-solving situations are given much more attention. ... The method of checking and rechecking to locate an error (or series of errors) within a given problem is more easily motivated when using a given problem on the computer. (May/83)

Many students commented on the holding power of working on a computer program and the drive to see a task correctly completed. However, success is not always assured and a teacher needs to be sensitive in order to be able to help students overcome frustration and blockages. "Failures" did occur. For example, one of the researchers recorded the following while visiting an intermediate-level class.

> Corrine showed me a program "BEE". She was upset and confused because it didn't work. 'It worked fine yesterday.' The error message said there was no procedure CIRC in 'BEE'. She explained that she got the CIRC program from Wendy and Karina. I guess she didn't save it. I suggested that she rewrite it herself. She knew it was a half circle and she knew to make a circle, but she would have to experiment to get the right sized half-circle. She called me back very frustrated and said she couldn't do it. She had no idea what was being repeated or what the effect might be of varying the numbers in the circle formula. She could not make a half-circle. (Nov. 28/83)
>
> Steven & Soren tried to get the turtles to respond to collision. Mr. O'Sullivan gave them the manual to work from. ... They said they gave up because nothing they tried worked. (Nov. 19/83)

However, lack of success at a given task did not necessarily mean that students' disappointments caused irreparable harm, provided that the students also experienced intermittent successes. Working with Logo in a supportive environment had actually given many students the confidence to accept mistakes as an integral process in learning. As one intermediate-level student reported: "I like to work on the computer for fun and learn from my mistakes". Students also learned to suspend problems if they could not be readily resolved right away and to return to them with new energy and knowledge later. An entry in a computer journal from an intermediate-level student is one example that illustrates how students had learned to cope with temporary failure and remain confident in their ability to achieve future success:

> 82 11 02: Kristy and I tried to fix our hiccup. It wouldn't work again!
>
> 82 11 05: Today Kristy and I tried to fix it again. Finally it worked!
>
> 82 11 07: Today Kristy and I tried to make a new hicup. It's called hic. It worked first time tested!
>
> 82 11 08: Today Kristy and I tried to fix our star. It worked.
>
> 82 11 09: Today I made another star. It was called star 3. It didn't work. It didn't have the right angles on it.
>
> 82 11 10: Today I tried to fix my star. It finally worked.

Although many students employed a trial and error approach at some stages in working through a problem, the predominant thinking modality in programming and debugging is logic.

Logical sequencing and inferential or deductive reasoning can, therefore, be practiced in a concrete and meaningful context. Typical comments by teachers were:

> [Grade 1] Children discover that if commands are not entered accurately, then the output which they expected is not executed. They are learning to be precise, to be accurate and the importance of specific sequences. (May/83)
>
> [Grade 3] The concept of logical reasoning is easily explored using Logo. Even grade three students are aware if they have not 'thought through' what they are going to do it won't work. ... I'm not sure, but more students are beginning to think to the end of a piece of work and how to get there, than they were earlier in the year. This just may be maturity or both, I don't know. (April/83)
>
> [Junior] Logic is difficult to explain to junior grades! But when children use logical thought processes to solve programming procedures, logic itself is practiced ... (May 15/83)
>
> [Emotional Adjustment Class] The use of "steps" in a procedure can be interestingly investigated and testing these over and over can be fun on the terminal. Logical sequencing is an important skill to learn, but difficult to teach and show. It is made easier and more rewarding with the computer. (May/83)

Logo also offered an opportunity to explore logical sequencing and reasoning in a linguistic context through interactive procedures that used the text and list capabilities of the language. Flow charting was also practiced in laying out the path of the various options and alternatives when designing interactive stories.

Additional problem solving situations were created as some students coped with catching up with missed lessons and assignments while they were working on the computer. Social problem solving was evident in resolving how to work in pairs at a computer and in finding strategies that could resolve conflict. One teacher commented that "students share ideas and work together with an air of purposeful co-operation which I have never seen in my 19 years of teaching". On a larger scale, many students were involved in designing a computer schedule for the whole class. In one class, students were involved in designing a simplified version of Logo for Kindergarten children. During this process they had to consider the needs of a young child and to choose appropriate strategies.

All teachers felt that this extensive problem-solving experience could not be easily duplicated in any other medium. Two intermediate-level teachers felt that the degree of learning that can take place in this area is sufficient to justify the use of Logo in education.

> [Intermediate] There is a concern that Logo doesn't adequately replace specific content in

> the Grade 8 curriculum. I think these concerns are not justified. The problem solving skills alone which the child learns are enough to justify his time on Logo. I'm attempting this month to implement some geometric construction work on the Logo classes. (Jan. 13/83)
>
> [Learning Disability Class] Problem solving is not only important to almost all areas of curriculum but could almost be listed as a necessary "survival skill". It is so very important that a child learn to be able, when faced with a problem to step back, look at it, figure out the alternatives and make a decision - come to think of it - it's not a bad skill for adults to learn as well. (June 10/83)
>
> [Intermediate] A lot of money has been spent teaching teachers how to do creative problem solving. The children do this quite naturally in the classroom. They are daily comparing each other's procedures. They are looking at the products that other children get. They are looking at the hard copies. They are receiving back hard copies with written direction as to things they could do to change or improve procedures that they have made. They find that comparison is a very important part of computer classroom. This could be done with other software; not only Logo. (Dec. 15/83)

Whether there is a transfer of problem-solving skills from the computer domain to other areas remains a problematic issue. However, teachers commented quite frequently that they perceive that such transfers did occur:

> [Grade 3] The concept of "pattern thinking" has certainly been carried over. Sharing of ideas - making decisions like choosing and carrying out tasks - all improved. Learned to respect other people's ideas and work. (April/83)
>
> [Emotional Adjustment Class] We have done much work in this area during the year with kits such as the THINKLABS. The children were able to work well through these exercises in logical thinking. Working with the computer enhanced these skills the most. (June 20/83)
>
> [Junior] I'm not sure if I'm imagining it or whether it's wishful thinking, but the kids seem to be thinking more and more for themselves. Robert who is extremely hesitant and worried about how he's doing, if he's right, etc., came to me today to check with me but suggested what he thought was right. When I affirmed this, he said "I thought so!". It may not seem a big thing, but for him it is. (Oct. 27/82)
>
> [Junior] The transfer seems to occur from solving problems at the computer to solving

> day to day problems in the class. They are more willing to think creatively and logically in other areas, especially in the area of social relationships. When someone brings up a problem at a class meeting, the others readily offer suggestions for solving it. "Have you tried", "I had a problem like that and I ...", "Have you spoken to ... ", etc. (Dec.13/82)
>
> [Intermediate] The reality of the computer is that it is interactive and that nothing is final; each stage can be changed to suit the new set of circumstances. Paper doesn't lend itself easily to that concept. Is there a transfer of this effect from computer activities to other areas of the curriculum? I think so. I don't know how to measure it. I see things happening that are visual things within the classroom in how children organize and do things; how they plan projects; how they organize field trips. I see it, but for me to measure it and say this is the result of the computer, I can't answer that. (Dec. 15/83)
>
> [Intermediate] One of the regular classroom teachers of the students who attended Logo sessions at Queen's said that she noticed that in science class the students who had been involved in the Logo project had a more systematic, logical approach to problem solving. This teacher also reported that "I believe Logo helps shape the way a person thinks. It teaches logical thinking, analysis, the ability to learn through deduction. The same way Latin and Greek were supposed to do (we were told) when we took humanities. (Jan./83)

Students themselves expressed a wide range of problem solving, thinking, and social skills that they felt they learned from working with computers or Logo (Table 24). Although the frequencies indicated in the table are not very great, it is important to note that these responses were given without any prompts.

When the focus shifted from "problem solving" to "problem creation", the computer in conjunction with Logo, graphics tablets, and music software aided in the generation of ideas. The ease with which it was possible to manipulate component parts, to "see what happens if" and to obtain fast feedback made it possible for students to become more creative. However, this process came easier to some students than to others. Students who tended to be less conforming, less concerned about grades or about pleasing the teacher, tended to plunge into expressing and exploring their own ideas sooner and with more enthusiasm than the more conforming students. The shy and insecure students - among them many high-achievers - needed a great deal of encouragement and a safe environment that would tolerate "stupid" ideas or

Table 24

"What have you learned from working with computers?"

"What have you learned from working with Logo?"

Responses Pertaining to Cognitive, Problem-Solving, and Affective Domain

	Primary	Junior	Inter-mediate	Total
No. of students sampled	114	84	154	352
	Frequencies			
Cognitive Domain:				
Thinking harder	1	3	4	8
Thinking by yourself	1		1	2
Has taught me concentration		1		1
It helps me have more thinking styles			1	1
Learn about people's way of thinking because they express it on the computer			1	1
Thinking of new ideas			1	1
To be creative			2	2
To use our imagination			1	1
Something new each day			1	1
To combine my partner's ideas with my my own			1	1
Problem-Solving Domain:				
When you make a mistake you try again	1	2	3	6
How to cope with problems better	1	1	1	3
How to give directions, proper instructions	2		1	3
Trying things out	1			1
To think problems out more easily on the computer		1		1
How to think things through		1	1	2
To be more logical, understand the logic of things			2	2
Helped me think what I was doing			1	1
Helps me attack problems from all angles			1	1
Has helped me learn new techniques			1	1
Affective Domain:				
To be confident		1	3	4
That I can fix every problem on the computer		1		1
To be very patient (with myself)		3	7	10
To share and cooperate with classmates			3	3
Social problems are sometimes solved			1	1
How to adjust to different atmospheres			1	1
Working can be fun			1	1
It has made me interested in computers			1	1
Me learning control over computer		1		1
Total	7	15	41	63

explorations that did not end with a "successful" product. In order to gain greater confidence in pursuing their own ideas, these students tended to work through several strategies:

1) rely on the teacher for initial suggestions, assignments, and challenges;

2) once they felt more secure in their ability to master the necessary "tools", they began to modify such tools or to draw on ideas from their peers;

3) if the experiences in the previous two stages were positive, they then gained further courage to rely on and explore with their own ideas, although a small number of students remained in stages 1 and 2.

Those students who generated many creative ideas tended to be free to experiment, be receptive to the unexpected, translate "failures" into positive acts, build on existing acts or ideas to create new ones, and draw from a wide range of experiences or knowledge. The following samples drawn from observations in a Grade 3 class were typical of the range of creative strategies in other classes:

> Rick and Lorne are making a space scene (part of a class activity). "Ronnie and Sean told us how to do the star 'cause we wanted to use it in a picture." The procedure is a variable procedure for star and the boys are making use of many different sizes. They are so eager to share their plans. They want to make a lot of planets and a rocket. They are so enthusiastic! (Jan. 17/84)
>
> Heather and Darlene are making circles. They have increased the number of repeats from the REPEAT 40[FD 6 RT 6] they tried with the whole class. Now they are using REPEAT 60[FD 6 RT 6] and are very excited to have completed circles. I don't know how they arrived at this number. They typed:

```
REPEAT 60[FD 6 RT 6]
REPEAT 60[FD 6 LT 6]
         BK 10
REPEAT 60[FD 6 RT 6]
REPEAT 60[FD 6 LT 6]
         BK 10
```

> They repeated this pattern many times all the while discussing the changing image on the screen. "It looks like eyes" said Heather, "Or a pumpkin if you look at it this way". Darlene thought it could be an eight. After they had filled the screen with repetitions I heard an excited "OH! Now it's a slinky." They didn't save their picture, however, they did dump it out. They explained to me that it was a very big picture and would have taken too much room on the disk. (Oct. 6/83)
>
> Leonard and David are making a giant sucker. They are using a procedure called ESE which

> takes a variable input and makes a ring. They keep stopping it and then using a smaller input. The result is a shape that seems to spiral inward. ... They called me back later saying: "We just invented a new way to make a circle." They used:
>
> ```
> TO CIRCLE :SIZE
> REPEAT 13[FD :SIZE RT 45]
> END
> ```
>
> As long as they give it a small input, it does look like a circle. (Jan. 11/84)
>
> Sarah is working alone today. She is making a spring scene. She has a tree and a butterfly and is now trying to make a sun. She has trouble with her sun and turned it into a bee. She was obviously proud of this turn of events. She explained that her circles were all too small and she didn't know how to make them bigger. She has not solved her problem with circles but she has solved the problem of the picture's composition. The bee is very convincing and fits well into the scene. (Jan. 11/84)
>
> Ingrid is at the keyboard, her fingers flying. She saw a "wrapped" circle as a window curtain so she added the window panes to complete the picture. (Feb. 22/84)
>
> Kelly called me over to the computer yesterday to show me her procedure to DRAW:
>
> ```
> TO D
> DRAW
> END
> ```
>
> She said she was tired of typing DRAW every time!! I thought this was very ingenious of her. (May 2/84)
>
> Leonard and David have made a program called REWQQERT. It is a long line of commands and all the FD commands are variable (:L). They were elated. "we just fooled around and made it", they said. "Let's do different sizes". They tried 4, 12, 1 and then 50. After each try they changed the background colour and commented on the many nice results. (March 9/84)

Being creative on demand (i.e., during the students' scheduled computer time), and predominantly within one setting (turtle geometry), became a burden for students at times. It was not always easy to think of exciting ideas and, on occasion, even teachers' challenges - "just squares, circles, triangles, etc." - became boring. The following responses by intermediate-level students were also expressed by other students at times:

> One thing I've noticed is that I am getting bored. Maybe it's just me but I am running out of ideas.

> Lucy and I often sit back there at the computer with nothing to do.
>
> Before we would try everything, and everything was great, even just a bunch of lines, but now it's getting harder.
>
> Our activity on the computer did not give us any ideas but Mr. O'Sullivan said we weren't being creative so we plan to show him otherwise. We are going to make a horse move across the screen. It may take awhile.
>
> We really weren't all that creative at the end of the week.
>
> I think when you are just using Logo and Bank Street Writer and you work with them every day, it gets boring. I'd rather work with BASIC or play games now.
>
> When I first came to school it was "wow, we have computers" - but for the last few months Logo it has been getting considerably boring each time you work on it because it is not new to us, we know everything - or not everything, but we've been working on the same stuff for 8 months so when I go home I work on BASIC.

The need for variety and progress became particularly evident with students who had been in the study for two years. Some of these junior and intermediate level students found that "it was much more fun last year because we were always learning new stuff". None of the teachers in this study who had students for a second year were able to familiarize themselves sufficiently with the more advanced capabilities of Logo or to think of more advanced "creative" challenges for their students. The lack of advanced courses in Logo or advanced courses on computers in education became a problem for the teachers as well.

20. MATHEMATICS

The designers of Logo referred to the turtle geometry component of Logo as a mathematics laboratory. The central features of a laboratory setting are experimentation and acceptance of the unexpected with the attendant next steps that lead to questioning, problem-solving, and discussion. The teachers in this study accepted and encouraged such a mode of learning quite readily at the computer and found that the computer and Logo readily facilitated it in exciting ways. This context of experimentation allowed students (even the very young) to explore mathematics in a rich environment that went beyond the numeric. In addition, the computer demanded precision and was unforgiving - but in a nonjudgemental way. If the computer received an invalid command, it would merely give an error message and stop. If students put in syntactically valid commands, then they would know almost instantly whether their instructions achieved the desired result or not. Perhaps for the first time, students could experience a real and immediate need for precision. The major justification for attending to details and for learning new facts and procedures was in the manifest result rather than a good grade on a test or report card, or the distant promise from adults that "some day you'll understand why you need to learn this". These conditions created a positive psychological climate and offered new instructional strategies for the teachers in the traditional teaching of mathematics. For example, one intermediate-level teacher found that:

> I have learned, partly through working with students and computers, that there is an affective component to understanding a concept that is at least as important as the cognitive component. This affective component comes about through certain creative experiences, e.g., one student told me "I've thought about circles in ways I've never considered before". (June 3/83)

The fact that most students saw a real purpose for and had control over their activities was a powerful motivator. This was particularly true when students were involved in problems of their own choosing. In an environment that gave a student some autonomy and where the teacher created an atmosphere in which mistakes were seen as a natural and healthy part of the learning process, many students retained or developed confidence in their ability to learn from their mistakes and to "get it right eventually". For example, one of the researchers (observing a Grade 1 student) recorded the following in her notebook:

> Robert is working at the TI computer. He shows me how he can make the sprites disappear. He then shows me how he can change

> to Logo. He uses cards with single commands, eg., FD 133. He reads the three digit number correctly. He talks as he goes along and keeps saying "it's magic". He constantly changes the background colour. He wants to make a new sprite and types in SM and the computer replies TELL ME HOW TO SM. Robert easily reads that and says to himself: "I want it to make a shape. Oh, maybe it's MS!" It works and he tells me he is going to make a stairway, which he does. He turns to me and very seriously says "I say, never give up!" (Jan. 12/84)

Journal entries by two students, one from a learning disabled class and the other from an intermediate-level class, illustrated typical reactions by older students:

> The first day I used the computer in our class. It was very exciting. I discovered angles to make octagon and other strange things to make. The first thing we did on the computer was our initials. It took a lot of time to finish it and it was a lot of fun. ... It made me realize that computer can help me in my learning as in my spelling and remembering. (May 19/83)
>
> Brenda and I tried out our house but we goofed. Brenda's house turned out perfectly. I hope to have better luck next time. (Oct. 5/82) ... Brenda and I tried to make a house. We did not succeed. We tried to make a circle, and succeeded. We did pick up some hints. I think we will be able to make a house the next time. (Oct.7/82)

Learning mathematics through turtle geometry made it possible to broaden the narrow, but commonly held, view of mathematics as being an immutable activity whose rules are "engraved in stone", to a dynamic activity with many viewpoints. Turtle geometry created an awareness of the arbitrariness of mathematical notation. For example, turtle geometry uses some arithmetic notations that are different from conventional notations. Also, through the use of some of the language's "primitives", students had an opportunity to look at standard operations in a new way. For example, a Grade 3 teacher whose class was considered to be "below average", reported that:

> Teaching multiplication tables. I put the following on the blackboard: 4 8 12 16 20 24 28 32 36 40 44 48. The children were able to see the pattern straight away. They even used the word REPEAT in describing what they noticed. This is the first time this has ever happened in my grade three class. I am sure it is because of their Logo work. They are looking for patterns in things more than they used to do. (Feb. 21/83)

Turtle geometry also facilitated the discovery and examination of standard geometric and mathematical terms and concepts. For example, a junior-level student who had been using

CIRCLE from a utility disk without ever examining the instructions for it, excitedly shared a new discovery with one of the researchers during one of her regular visits:

> Alan calls me over "Look Mrs. Moore we made a circle without using CIRCLE". (It was actually only a semi-circle but they were very excited because up until now they had always used the circle procedures on their disks to make circles.) I asked them how they did it. They showed me REPEAT 12[FD 12 RT 12]. "How many degrees must the turtle turn to get all the way round the circle?" "360" Kevin answered straight away. "How many degrees did it turn in your picture?" "Umm ... 12x12" answered Kevin. "Good, can you get it to make a circle now?" Kevin began to work on it. (Dec. 9/83)

During a visit to a Grade 3 class, the researcher was able to share another discovery about circles with students who, a few weeks earlier, had been given the "formula" for a circle by their teacher:

> "We discovered two new circles! One is huge. We called it HUGE in our notebooks." REPEAT 90[FD 20 LT 5] and REPEAT 30[FD 10 RT 40] Larry volunteered that the numbers don't multiply to 360 but it makes a circle anyway. The expression on his face told me that this was a wonderful discovery. I agreed. (Dec. 9/83)

Some students discovered that certain instructions made a circle "rounder" than others and that they could all be made from using REPEAT ___ [FD ___ RT ___] which, by varying the input for the angle, could create any polygon. This made the circle a natural member of the family of polygons. Given to intermediate-level students, a challenge to make a "filled in" circle, produced eleven different approaches or "solutions"; some of them more efficient with respect to execution time than others. This diversity in approaches could also be seen in students' responses to many other "challenges". Observing each other's work, students could see that a given task could be achieved not only by one "correct" route but by several. Turtle geometry also dispelled the common notion that the learning of mathematics can only occur in a highly sequential order. This became particularly evident in the learning disability class, where the teacher reported that:

> Geometry was not an area covered extensively in my class as many of these children have difficulty attaining a mastery of basic operations. ... Most of my class easily figured out square, triangle, rectangle with very little knowledge of geometry, angles, etc., save names of basic shapes. One boy was able to discover making of a circle on his own (had previous knowledge of REPEAT usage). Others kept trying - some got very close - word leaked out fast once a circle was discovered. The class was anxious to try half circle, etc. ... Therefore, a concept that would not necessarily become available to

> these students was presented - it is certainly one I will not ignore again - but without a computer I believe the amount of personal discovery will be limited. (June 20/83)

A junior-level student commented that "with Logo I am doing things in math before we ever learn it". These features created the potential for even young students to have a vision and understanding of mathematics which traditionally has been reserved for the graduate student or the scholar of mathematics. Just how unfamiliar this view of mathematics was to students was evident from comments made by students, such as:

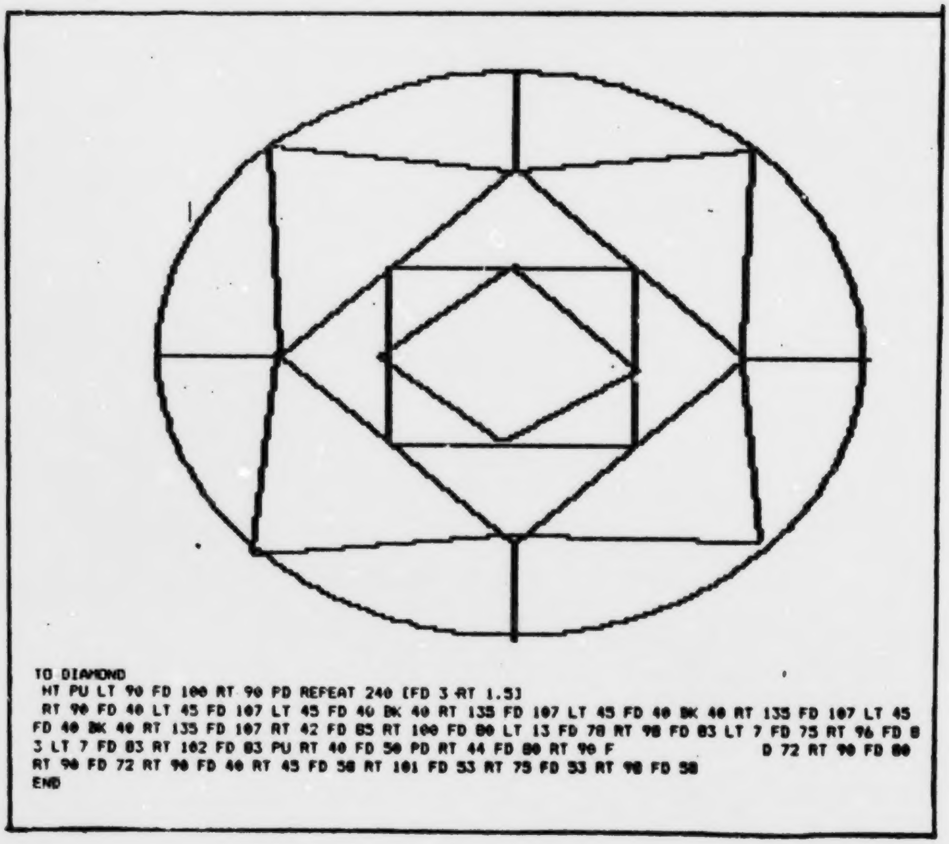
> [Junior] Logo is like learning math and having fun at the same time. (April/83)
>
> [Junior] Because if you are doing math and you are getting sick of it and then you go to the computer you get relaxed and when you get back to the math you are feeling better. (April/84)
>
> [Intermediate] The computer gives you a break and your mind can change over to the computer and then you go back to school work and you can think and work better at that subject. (May/84)

Turtle geometry, therefore, helped tc "set the stage" for mathematics and helped to focus on the "props" as well. The accessibility of Logo to the very young and its "natural" logic allowed students of any age and ability to explore and "play" with numbers and mathematical concepts in a way that made abstract ideas concrete, and that gave visually pleasing results. This power of making the abstract concrete was particularly important for one of the learning disabled students. A researcher visiting his class recorded the following observation:

> When I arrived, Walter was working at his desk doing standard addition and multiplica-tion problems. His teacher informed me that he needed to do at least two sheets of these every day because he still hadn't mastered the arithmetic operations. He was allowed to use "crib sheets" but encouraged to try to use them as little as possible. Walter had great difficulty doing the exercises and did not enjoy them. Right after he finished his drill problems he sat down at the computer and proceeded to draw a circle. By means of a series of "leading questions" from me, he was able to determine the appropriate number of repeats for a circle with an angular rotation of 1.5 degrees. He then set out to inscribe a "diamond" inside this circle. He proceeded by trial and error, estimating how far the turtle needed to move or turn before typing in the instructions. While doing this he added two digit numbers in his head with great ease. I could not believe it. Here was a boy, who only ten minutes earlier needed a "crib sheet" and here he was engaged in very quick and sophisticated arithmetic work. ... (Next visit:) Walter was eagerly looking forward to my visit because he had finished his DIAMOND

Figure 20.1

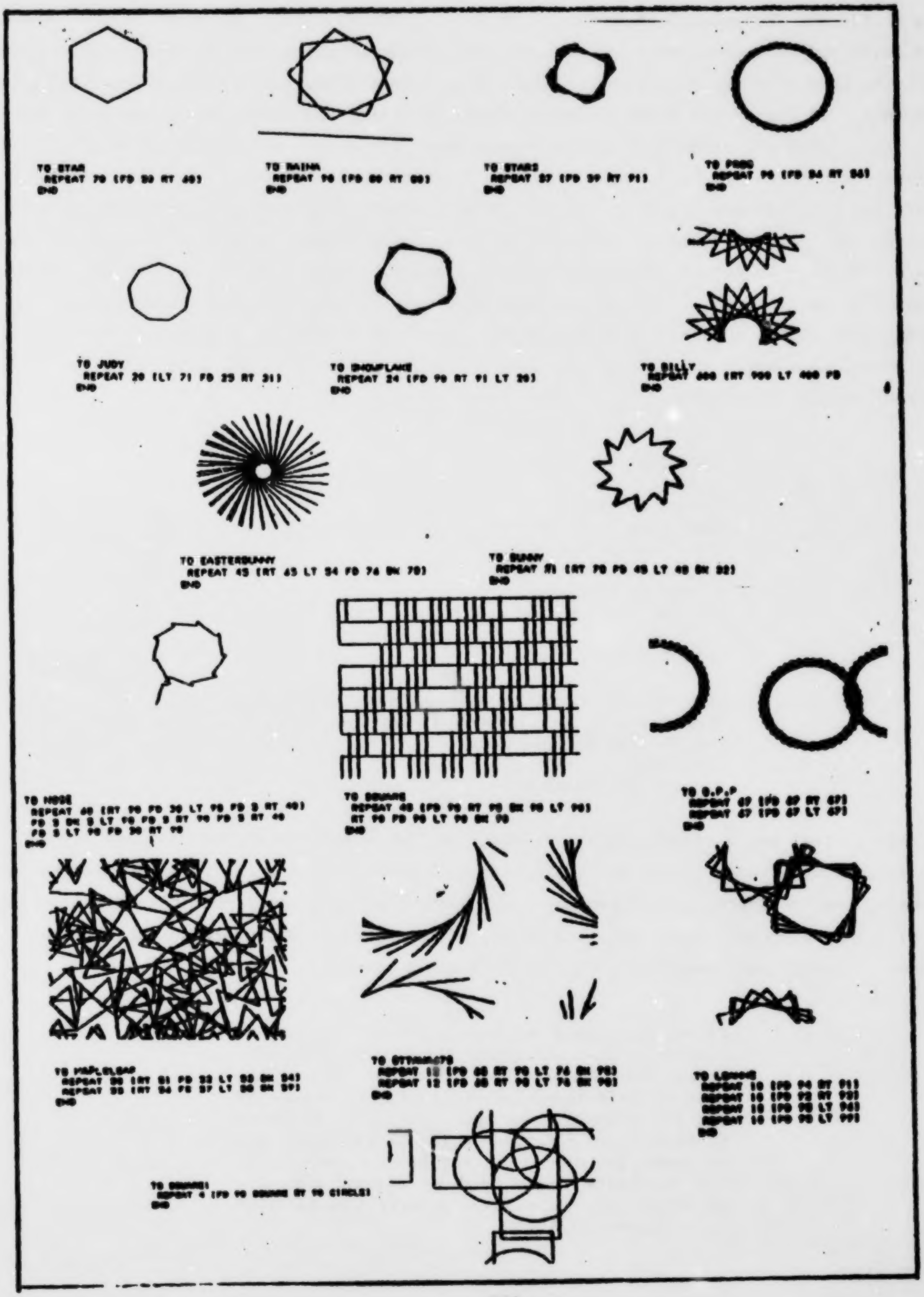
'DIAMOND' Design Created by a Student From the Learning Disability Class Using Logo



```
TO DIAMOND
 HT PU LT 90 FD 100 RT 90 PD REPEAT 240 [FD 3 RT 1.5]
 RT 90 FD 40 LT 45 FD 107 LT 45 FD 40 BK 40 RT 135 FD 107 LT 45 FD 40 BK 40 RT 135 FD 107 LT 45
FD 40 BK 40 RT 135 FD 107 RT 42 FD 85 RT 100 FD 80 LT 13 FD 78 RT 98 FD 83 LT 7 FD 75 RT 96 FD 8
3 LT 7 FD 83 RT 102 FD 83 PU RT 40 FD 50 PD RT 44 FD 80 RT 90 F            D 72 RT 90 FD 80
RT 90 FD 72 RT 90 FD 40 RT 45 FD 58 RT 101 FD 53 RT 75 FD 53 RT 98 FD 58
END
```

Figure 20.2

Examples of Explorations in Turtle Geometry by Two Grade 2 Students During the First Year of the Study



```
TO STAR
 REPEAT 70 [FD 50 RT 40]
END

TO RAINA
 REPEAT 90 [FD 80 RT 80]
END

TO STARS
 REPEAT 37 [FD 39 RT 91]
END

TO FROG
 REPEAT 90 [FD 84 RT 86]
END

TO JUDY
 REPEAT 20 [LT 71 FD 25 RT 31]
END

TO SNOWFLAKE
 REPEAT 24 [FD 90 RT 91 LT 20]
END

TO BILLY
 REPEAT 400 [RT 900 LT 400 FD
END

TO EASTERBUNNY
 REPEAT 45 [RT 45 LT 34 FD 74 BK 70]
END

TO BUNNY
 REPEAT [illegible] [RT 70 FD 45 LT 48 BK 32]
END

TO NOSE
 REPEAT 40 [RT 90 FD 30 LT 90 FD 3 RT 40]
 FD 3 BK 3 LT 90 FD 3 RT 90 FD 3 RT 40
 FD 3 LT 90 FD 30 RT 90
END

TO SQUARE
 REPEAT 40 [FD 90 RT 90 BK 90 LT 90]
 RT 90 FD 90 LT 90 BK 90
END

TO G.P.P
 REPEAT 67 [FD 67 RT 67]
 REPEAT 67 [FD 67 LT 67]
END

TO MAPLELEAF
 REPEAT 90 [RT 51 FD 33 LT 53 BK 34]
 REPEAT 30 [RT 54 FD 37 LT 30 BK 37]
END

TO [illegible]
 REPEAT [illegible] [FD 48 RT 90 LT 76 BK 90]
 REPEAT 12 [FD 48 RT 90 LT 76 BK 90]
END

TO [illegible]
 REPEAT 10 [FD 94 RT 91]
 REPEAT 10 [FD 72 RT 73]
 REPEAT 10 [FD 90 LT 98]
 REPEAT 10 [FD 90 LT 99]
END

TO SQUARE1
 REPEAT 4 [FD 90 SQUARE RT 90 CIRCLE]
END
```

In order to get "neat" results from large numbers, however, even Grade 1 children quickly learned that the turtle had to turn sideways and not straight up or down. One of the Grade 3 students knew that in order to get a "diamond" design all over the screen, she needed to give the turtle the following instructions: RT 45 FD 10000 PU HOME LT 45 PD FD 10000. However, she could not tell what "that big number" was. Students enjoyed these "wrapping" designs and enriched them with colour patterns. Such designs were often referred to as "quilts" by older students. In one of the Grade 1 classes these "quilting" patterns became backdrops for other artwork. A Grade 1 student in another class wrapped the turtle until he had a totally white screen which he called "a piece of paper". Students in one of the Grade 1 classes found their own personal meaning of a "really" large number. Before leaving the classroom for recess, they entered REPEAT, a number, and some instructions. At the end of recess they would rush back to see if the turtle was still going. If yes, they knew that the number was huge. The fascination that large numbers have, even for junior-level students, was exemplified by the numbers students used in creating a recipe for a witch's brew (an assignment that was to be done on the word processor). One such recipe offered the following ingredients and directions:

> INGREDIENTS
>
> 5 cups of wart
> 9000 cups of frog legs
> 9999 cups of human blood
> 63 cups of turtle eyes
> 7 cups of fish eggs
> 90 cups of pigs tails
>
> DIRECTIONS
>
> Mix together till smooth and delicious.
> Preheat oven to 100000000 degrees celsius.
> Put in oven for one hour.
> Take out.
> PIG OUT and SHARE IT!

No real context could offer students feedback on the meaning or effect of these large numbers. Other students extended their play with numbers to include more advanced notions of numbers, such as fractions and decimals, and embedded them in more intricate designs (Figure 20.3). Some students, especially the young, often expressed a preference for certain numbers. One of the researchers observed a Grade 1 student:

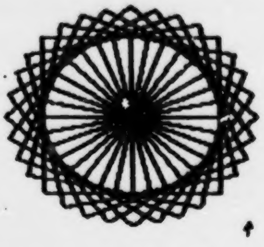
> Brent was trying to draw a house. He knew he wanted to make a square first but instead of using the formula for a square which the teacher gave them, he was trying to figure it out for himself. He typed FD 43 RT 43 FD 43 RT 43 and got a crooked wall. I asked him why he chose the number 43 and he told me it was his favourite number and he always uses it. At this point the crooked wall was OK with him. (April 17/83)

Figure 20.3

Examples of Early Explorations with REPEAT Statements

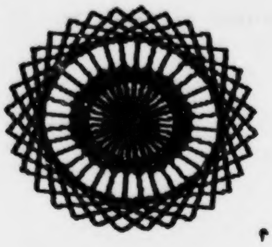
Collected From a Grade 6 and a Grade 8 Class

GRADE 6

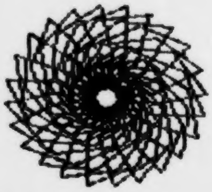


```
TO SQ.2
 REPEAT 4 [FD 25 RT 90]
END

TO SQ.1
 REPEAT 4 [FD 50 RT 90]
END
```

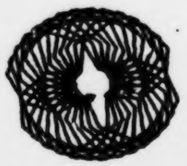
```
TO WEB
 REPEAT 8 [SQ.1 RT 45] REPEAT 8 [SQ.2 RT 45]
 REPEAT 16 [SQ.1 RT 22.5] REPEAT 16 [SQ.2 RT 22.5]
 REPEAT 32 [SQ.1 RT 11.25] REPEAT 32 [SQ.1 RT 11.25]
 REPEAT 32 [SQ.2 RT 11.25]
END
```



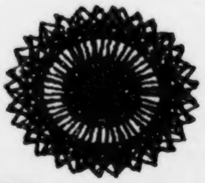
```
TO MYSTERIOUS
 REPEAT 8 [SQ.1 RT 45]
 REPEAT 16 [SQ.1 RT 22.5]
 REPEAT 32 [SQ.1 RT 11.25]
END
```



```
TO STAR
SETBG 5 REPEAT 25 [RT 90 FD 40 LT 45
 FD 40 LT 115 FD 40 LT 45 FD 40 LT 45
 FD 40  LT 125 FD 40]
END
```

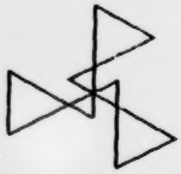


```
TO ROCK
REPEAT 25 [RT 90 FD 40 LT 45 FD 40
LT 45 FD 40 LT 45 FD 40 LT 45 FD 40
LT 45 FD 40 LT 45 FD 40 LT 5]
END
```

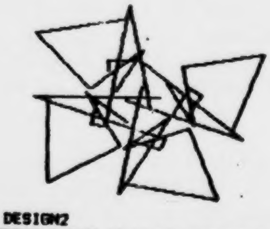


```
TO STAR250
REPEAT 100 [SETBG 8 SETPC 1 LT 90
FD 40 RT 120 FD 40 LT 59 FD 40
RT 120 FD 40 LT 59 FD 40 RT 120
FD 40 LT 59 FD 40 RT 120 FD 40
LT 59 FD 40 RT 120 FD 40 LT 59
FD 40 RT 120 FD 36]
 END
```

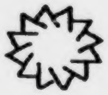
GRADE 8



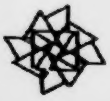
```
TO FLASH
 REPEAT 7 [FD 50 RT 120
 FD 70 RT 240 FD 90 RT 120]
 END
```



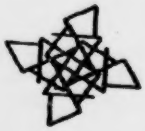
```
TO DESIGN2
 REPEAT 4 [FD 10 RT 90 FD 20 RT 120
 FD 30 RT 180 FD 40 RT 200 FD 50
 RT 90 FD 60 RT 120 FD 70 RT  90 FD 80
 RT 180 FD 90 RT 200 FD 100 RT 90]
 END
```



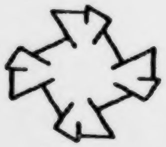
```
TO DESIGN3
 REPEAT 12 [FD 10 RT 90
 FD 15 RT 120 FD 20 RT 180]
 END
```



```
TO DESIGN4
 REPEAT 4 [FD 20 RT 90 FD 25
 RT 180 FD 30 RT 120 FD 45 RT 90
  FD 25 RT 120 FD 35 RT 180 FD 35
 RT 90 FD 20 RT 120]
 HT
END
```



```
TO DESIGN5
 REPEAT 4 [FD 40 RT 90 FD 60
 RT 180 FD 80 RT 120 FD 36
 RT 180 FD 30 RT 90]
 END
```



```
TO DESIGN6
 REPEAT 4 [FD 10 RT 180 FD 15
 RT 120 FD 20 RT 90 FD 25 RT 180
 FD 15 RT 120 FD 30 RT 90 FD 10
 RT 180 FD 35 RT 120 FD 25 RT 90]
 END
```

Since turtle geometry was designed to facilitate the drawing of lines, many explorations quickly became explorations in geometry. Primary- and junior-level students usually do not have the fine motor control nor the patience to use conventional materials, such as paper and pencil, compasses, rulers, and protractors to experiment and explore to the extent or speed that the computer allowed them to do. As one teacher commented:

> A Grade 3 student could only explore in the real world, not create their own pattern, designs, figures, etc. They do not have the skills required but the "turtle" has. (April/83)

As students made drawings of the various designs or specific geometric shapes, they often had to carry out arithmetic operations on numbers. Many students developed a "sense" of numbers, angles, distance, and estimation within the context of geometry. By means of trial and error, estimation, and direct calculation, they developed and sharpened their skills and judgement.

Through turtle geometry, young students became familiar with shapes such as squares, triangles, rectangles, pentagons, hexagons, octagons, and circles, not only as entities to be recognized, but also as shapes that they could readily modify or change, create over and over again using different dimensions, positions, and rotations, and which could readily be used as building blocks in other designs. Although some students remained comfortable following instructions, others explored and extended known shapes and "formulae". The following observations give a flavour of some primary students' activities:

> [Grade 1] Frankie explained to me that he was "making another circle inside this one". I asked him how he knew it would fit inside and he answered confidently that it would, because he was using a smaller number of FD. (March 17/83)
>
> [Grade 1] Michael and John drew a star, REPEAT 144[RT 144 FD 100]; they did not use the cards [teaching cards] to help them. Michael types another REPEAT asking John for a number. REPEAT 8[RT 88 FD 50], REPEAT 4[RT 200 FD 30]. Michael exclaims "Oh it's a little star that's not quite finished". John types another REPEAT 9[RT 56 FD 44]. Michael noted that "it's almost a star made out of a hexagon, silly isn't it". I asked him if he knew what a hexagon was, and he told me it had 6 or 8 sides; he wasn't sure which. (March 23/84)
>
> [Grade 2] Most have the idea of a square now. Many have made adjustments to make various sized squares. (Dec. 3/82)
>
> [Grade 2] Dianne and Andrea had made a square for the bottom of a house and asked me how to make the turtle go that way to make the top. I answered that it looked like the turtle would have to turn before he went forward. They tried LT 10 (wrong direction and much too

> small an angle). Realizing they had turned the turtle the wrong way, they then typed in RT 120 which pointed the turtle into the square. Again, not a good estimation. At this point they gave up on the house and decided to draw lines inside the square. (May 12/83)
>
> [Grade 3] Lynn and Karen have put an octagon, hexagon, and pentagon on their screen, one inside the other. They have repeated this on the left side of home. They named the shapes for me and explained how they had used the REPEAT to make different shapes. "REPEAT 8 makes an octagon, REPEAT 6 makes a hexagon and REPEAT 5 makes a pentagon." They called their picture "tunnel". I wasn't sure that they weren't just remembering the formula from their notebooks, so I asked if the shapes got smaller because the repeat number got smaller. They explained that "that number is for the sides. We used a smaller number of FDs and that made it smaller." They certainly know which part of the procedure does what. (Dec. 9/83)
>
> [Grade 3] Heather and Darlene are making a windmill. Heather said she was trying to make "something with triangles that goes all the way around" and when she did it, it looked like a windmill. She used a procedure for triangles and put RT 30 between each triangle. How did she know that it would go all the way around? "We just found out when we did it!" They put another triangle at the bottom of the picture to represent the tower for the windmill. (Dec. 9/83)
>
> [Grade 3] Ingrid and Jenny made a filled-in circle by rotating a square 360 degrees. "It is variable", she told me proudly. She then did the same thing with rectangle, just to see if it would work. They are making a picture of a book and have used the rotating square procedure to make a blue pool on the front cover and rotating rectangle procedure to make a yellow sun. I asked her whether the colour could be variable too? "Oh sure", she answered in an off-hand way, and went on with her immediate task of drawing the head of the person behind the book. (March/83)

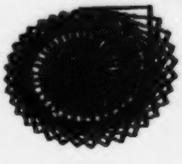
The Grade 3 teacher commented:

> I have found that angles and amount of turn can be explained so well using the turtle. Also my unit on shape recognition was easily done using Logo. (April/83)

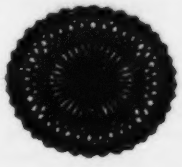
Explorations at the junior- and intermediate-level, provided there was appropriate teacher input and feedback, became more intricate and the programming features more advanced (Figures 20.4).

Figure 20.4

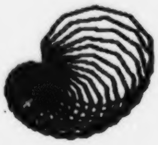
Examples of Explorations With Geometric Shapes by a Grade 6 and a Grade 8 Student



EDER 50



EDER1 30

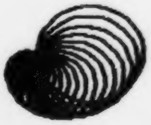


EDER2 25

```
TO EDER :S
REPEAT 4 [FD :S RT 90]
RT 10 EDER :S - .5
END
```

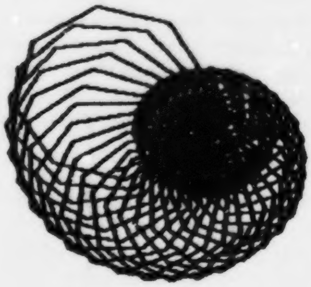
```
TO EDER1 :S
REPEAT 6 [FD :S RT 60]
RT 10 EDER1 :S -.5
END
```

```
TO EDER2 :S
REPEAT 10 [FD :S RT 36]
IF :S > 60 [STOP]
RT 10 EDER2 :S - 1
END
```



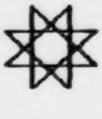
EDER5 20

```
TO EDER5 :S
REPEAT 36 [FD :S / 3 RT 10]
IF :S > 60 / 3 [STOP]
RT 10 EDER5 :S - 1
END
```

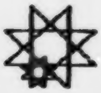


EDER4 25

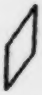
```
TO EDER4 :S
REPEAT 8 [FD :S RT 45]
HT
IF :S > 60 [STOP]
RT 10 EDER4 :S - 1
END
```



```
TO HITLER
 REPEAT 8 [FD 65 RT 135]
END
```



```
TO BOLD
 HT REPEAT 8 [FD 25 RT 135]
 HITLER
END
```

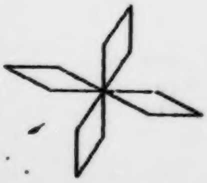


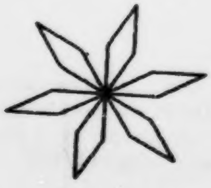
```
TO FOURSIDE
 REPEAT 2 [FD 60 RT 30 FD 60 RT 150]
END
```

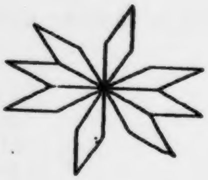
```
TO PINWHEEL
 REPEAT 4 [FOURSIDE RT 90]
END
```

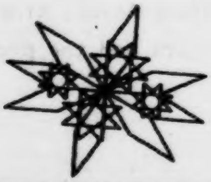
```
TO SUPER.PINWHEEL
 REPEAT 6 [FOURSIDE RT 60]
END
```

```
TO BIRD
 PINWHEEL
 SUPER.PINWHEEL
END
```









```
TO UGLY
 HT
 BIRD HITLER RT 180 HITLER RT 90 FD 30
 REPEAT 8 [FD 45 RT 135]
 RT 180 FD 60 REPEAT 8 [FD 45 RT 135]
 HOME
END
```

A junior-level teacher found that:

> Geometry comes alive. Slides, flips and transformations are easily understood, a concept which in former years seemed difficult to teach and learn. (Dec. 13/82)

And an intermediate-level teacher also remarked that:

> Children are very adequately handling such things as slides, rotations, flips. They have the opportunities to experience and draw mirror images, reflections. Many of these things I'm not working directly into the curriculum at this time. ... I have worked into the curriculum lines, squares, planes, multi-surfaced shapes, hidden lines and find that the children related to these very quickly. A sample of this would be the beginning of three dimensional work. (March/83)

A Grade 3 teacher commented that "it is far easier to explore relative size and symmetry in Logo" and "similarity is easily explained especially as the children are using variables such as size". The ease of superimposing shapes, and the need to examine which elements of a sequence of commands had to be different in order to obtain a symmetric design, made it easy to compare and to draw conclusions. Students spontaneously tended to make highly symmetrical designs and pictures, and it became easy for the teacher to use samples of the students' own work to explain these concepts. For example, two Grade 3 students working on a challenge "to make a heart" went about it the following way:

> They have the procedures for the two halves. They did one half and then reversed all the directions for the other half. Larry said "now the problem is putting them together, but we'll do it." (Feb. 9/83)

Two teachers at the intermediate level found that:

> Math Logo has prepared my class beautifully for lessons on lines, rays, points, rotation, angles, variables, shapes, the concepts of internal and external angles, decimal division and co-ordinates. (Dec. 2/82)

The primitives SETX, SETY, or SETXY, which were used to set the x-co-ordinate, the y-co-ordinate or the pair of x-, y-co-ordinates respectively, were easily handled by junior- and intermediate-level students as they attempted to place shapes and designs in different parts on the screen, since the HOME or (0,0) position of the turtle is in the middle of the screen. The concept of negative and positive numbers and various co-ordinate properties could be conveyed and grasped more readily by junior-level students. One intermediate-level student whose teacher gave his class an assignment on co-ordinates which had to be done first on graph paper and then on the computer, remarked:

> Even though I hated co-ordinates on the computer, I found co-ordinates, integers, etc., in math class super-easy. (April/84)

Students were also able to create designs within Logo with relative ease which otherwise would require a command of more advanced mathematical concepts for generating angular movement. For example, one primary and two intermediate-level students created "clocks", one with a pair of static hands and two that had one hand moving around the face of the clock (Figure 20.5). An intermediate-level teacher, while observing students engaged in such activities, recorded the following in his logbook:

> It is interesting to watch a student who from past record is not particularly good in math do problems on the computer that require an understanding of angular movement. I am thinking particularly of placing small marks at the perimeter of a circle. In math it requires not only the concept of perimeter but of arcs, of rays from a central point. The student using Logo can experience it by placing the turtle in the location he wants and as that placement sequence continues, he can develop a pattern for why it has unfolded. (Dec. 15/83)

A composite of the specific topics of the traditional curriculum that were covered while exploring with turtle geometry is presented in Figure 20.6. Several of the concepts could be introduced at a much earlier age than is currently practiced. Topics are now accessible to students in the elementary grades that are traditionally not taught until high school. The Grade 3 teacher reported that:

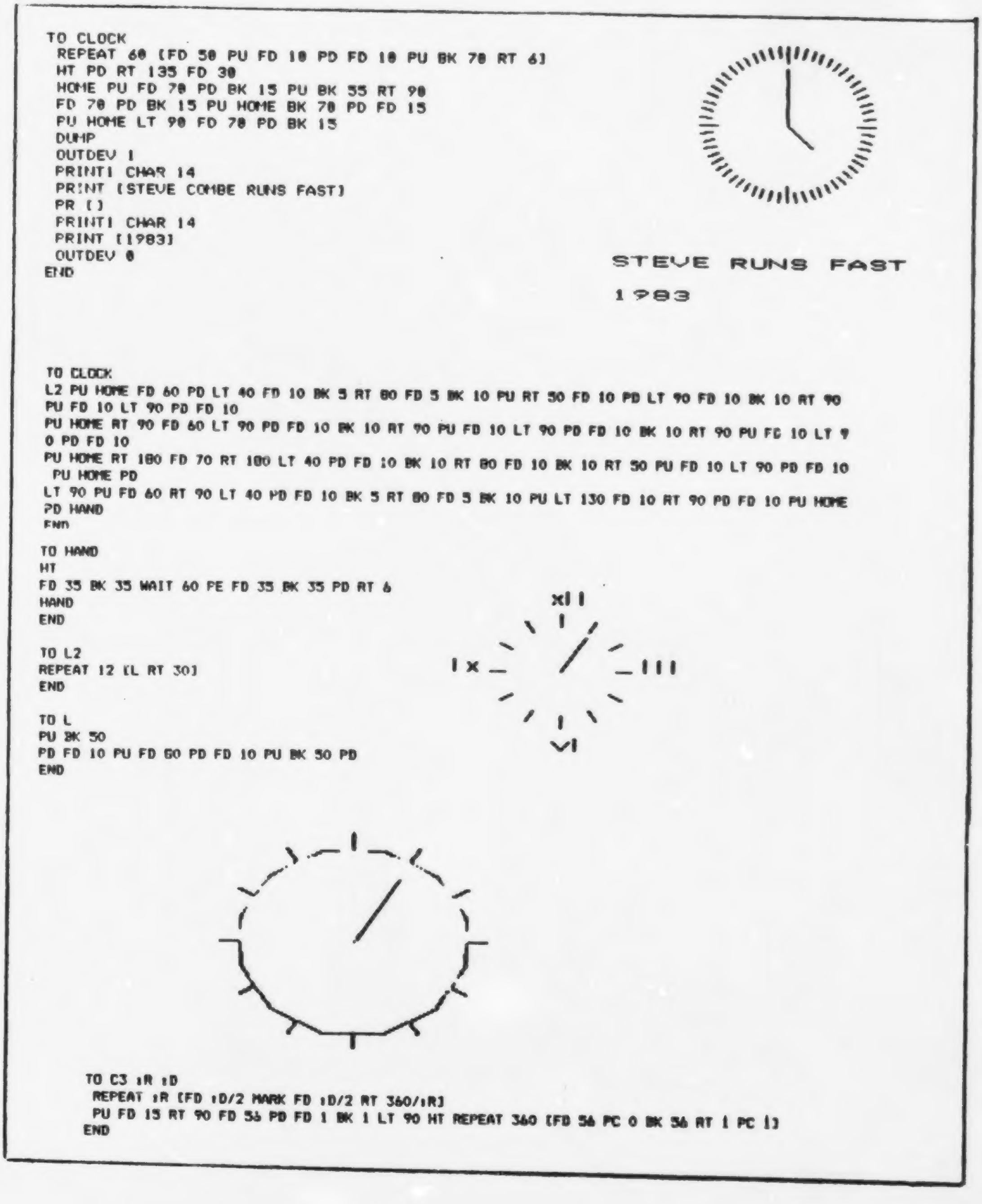
> Properties of congruency, similarity, and tiling are concepts that are not "taught" at the grade three level. Children working with Logo develop these concepts in a natural way. They become aware of them but have no idea what they are nor can they indeed put a name to them. (Dec. 15/83)

To a limited extent, students as young as Grade 1 were able to "play" with sets through the use of Logo music; older students also could do so through the use of list properties. Logo music required two sets of numbers, one representing the pitch and the other the duration of a note. Some of the Grade 1 students discovered quickly that each set had to have the same number of elements because the program simply would not work otherwise. A junior/intermediate level teacher found that using lists and the list properties, the concept of sets could be discussed very nicely, as the program handled these lists and picked from a list to do a particular job.

The concepts of randomness and transformations could be explored by taking advantage of the built-in primitives RANDOM and ASPECT (SETSCRUNCH), the latter representing a

Figure 20.5

Three Pictures of Clocks Produced in Logo: One Created by a Grade 8 Student That is Static, and Two Created by a Grade 3 and a Grade 7 Student That Have Moving 'Second' Hands



```
TO CLOCK
 REPEAT 60 [FD 50 PU FD 10 PD FD 10 PU BK 70 RT 6]
 HT PD RT 135 FD 30
 HOME PU FD 70 PD BK 15 PU BK 55 RT 90
 FD 70 PD BK 15 PU HOME BK 70 PD FD 15
 PU HOME LT 90 FD 70 PD BK 15
 DUMP
 OUTDEV 1
 PRINT1 CHAR 14
 PRINT [STEVE COMBE RUNS FAST]
 PR []
 PRINT1 CHAR 14
 PRINT [1983]
 OUTDEV 0
END
```

```
STEVE RUNS FAST

1983
```

```
TO CLOCK
L2 PU HOME FD 60 PD LT 40 FD 10 BK 5 RT 80 FD 5 BK 10 PU RT 50 FD 10 PD LT 90 FD 10 BK 10 RT 90
PU FD 10 LT 90 PD FD 10
PU HOME RT 90 FD 60 LT 90 PD FD 10 BK 10 RT 90 PU FD 10 LT 90 PD FD 10 BK 10 RT 90 PU FD 10 LT 9
0 PD FD 10
PU HOME RT 180 FD 70 RT 180 LT 40 PD FD 10 BK 10 RT 80 FD 10 BK 10 RT 50 PU FD 10 LT 90 PD FD 10
 PU HOME PD
LT 90 PU FD 60 RT 90 LT 40 PD FD 10 BK 5 RT 80 FD 5 BK 10 PU LT 130 FD 10 RT 90 PD FD 10 PU HOME
PD HAND
END

TO HAND
HT
FD 35 BK 35 WAIT 60 PE FD 35 BK 35 PD RT 6
HAND
END

TO L2
REPEAT 12 [L RT 30]
END

TO L
PU BK 50
PD FD 10 PU FD 60 PD FD 10 PU BK 50 PD
END
```

```
TO C3 :R :D
 REPEAT :R [FD :D/2 MARK FD :D/2 RT 360/:R]
 PU FD 15 RT 90 FD 56 PD FD 1 BK 1 LT 90 HT REPEAT 360 [FD 56 PC 0 BK 56 RT 1 PC 1]
END
```

Figure 20.6

An Extract From "The Formative Years" Showing the Specific Topics in Mathematics That Were Explored by Students While Using Logo

Arithmetic:

(Primary): Understand and use numbers and operations.
- count, group, and use notation for recording;
- master number facts related to addition, subtraction, multiplication, and division of whole numbers which are relevant to his or her experience;
- apply arithmetic to everyday problems and recognize through such activities the need for further skills.

(Junior): Use mathematical concepts and arithmetic operations with understanding.
- compute efficiently using standard algorithms;
- understand and use the commutative, associative, and distributive properties;
- relate the members of one set to members of another set using ideas of correspondence and mapping, including the interpretation and development of graphs, charts, maps, models, and other forms of representation;
- draw conclusions from evidence obtained through experimentation or logical reasoning and apply mathematics to the solution of everyday practical problems.

(Interm.): Numerical methods:
- collecting data, tally charts; constructing and interpreting bar and line graphs;
- operations with whole numbers and decimals, reasonableness of results; estimating answers; applications in real-life situations;
- concept of and computation with fractions; applications;
- modular arithmetics in real life: 12-and 24-hour clocks; week; months; year; 360 degrees in a complete rotation.

Measurement:

(Primary): Use measurement in relevant situations with an understanding of the concepts involved.
- match, compare and order lengths, areas, using appropriate terms;
- estimate quantities by sight, and confirm estimates by measurement.

(Junior): Consolidate and extend the measurement skills outlined for the Primary Division.
- estimate length, with an appropriate degree of precision.

(Interm.) Measurement of Length, Area, Volume.
- estimating and measuring lengths of line segments and curves, and the perimeters of figures;
- application of perimeters and area using measurement and/or calculation;
- investigateing circular objects to find circumference/diameter.

Geometry:

(Primary): Understand relationships involving space and shape:
- recognize spatial patterns in the environment;
- describe, identify, and classify objects by attributes such as shape;
- identify plane figures such as the triangle, rectange, square, pentagon, hexagon, octagon, and circle;
- recognize symmetry in two-dimensional figures;
- use introductory comparative ideas of scale such as twice as large, three times as long, half as high.

(Junior): Understand more complex spatial relationships.
- classify shapes in the plane (two-dimensional shapes) according to their attributes;
- discover patterns and identify properties of two-dimensional figures by tiling in the plane;
- develop concepts f symmetry related to point-, line-, plane-, rotational, and translational symmetry;
- identify the symmetries of figures in the plane and of objects in space;
- develop and use the concept of co-ordinates;
- understand, represent, and use concepts such as vertical, horizontal, perpendicular parallel, angle, triangle, and polygon;
- understand the concept of congruency.

(Interm.) Basic notions in geometry
- using geometric terms in correct contexts.

(Interm.) Constructions
- constructing congruent segments, congruent angles, perpendicular lines, perpendicular bisectors, angle bisectors, and parallel lines;
- constructing rectilinear figures;
- constructing special cases of triangles and quadrilaterals;
- locating the centre of a circle and of a circular arc; concentric circles.

Patterns With Tiles.
- fitting two or more congurent tiles; properties of the figures formed;
- relating slides, flips, and turns to figures;
- tanagram and polyomino puzzles; the symmetries of the tiles and of the figures.

(Interm.) Transformations
- image of a figure under a slide, flip, or turn;
- constructing translation, reflection, and rotation images; congruence of corresponding parts;
- line symmetry and rotational symmetry as mappings;
- drawing dilatation image; scale factor; properties.

(Interm.) Properties of Plane Figures
- properties of triangles, parallel lines, and quadrilaterals.

(Interm.) Three-dimensional Geometry
- sketching 3-D objects.

transformation of the y-co-ordinate. One teacher introduced RANDOM to her Grade 1 class! Some of her students enjoyed setting random background colours and by combining it with REPEAT, such as REPEAT 10[RANDOM BG4], could watch the effect as the screen flashed different colours. At the junior/intermediate level, some students extended their explorations to include random movements and turns such as:

```
TO HIC
REPEAT 500 [PC RANDOM 6 FD RANDOM 30 LT RANDOM
91 RT RANDOM 40]
END
```

The use of random pen-colours made it possible to observe the patterns that emerged and to compare various lengths and turns. One student also designed a random generator for the letters of the alphabet by using ASCI codes:

```
TO G
PR CHAR RANDOM 250
END
```

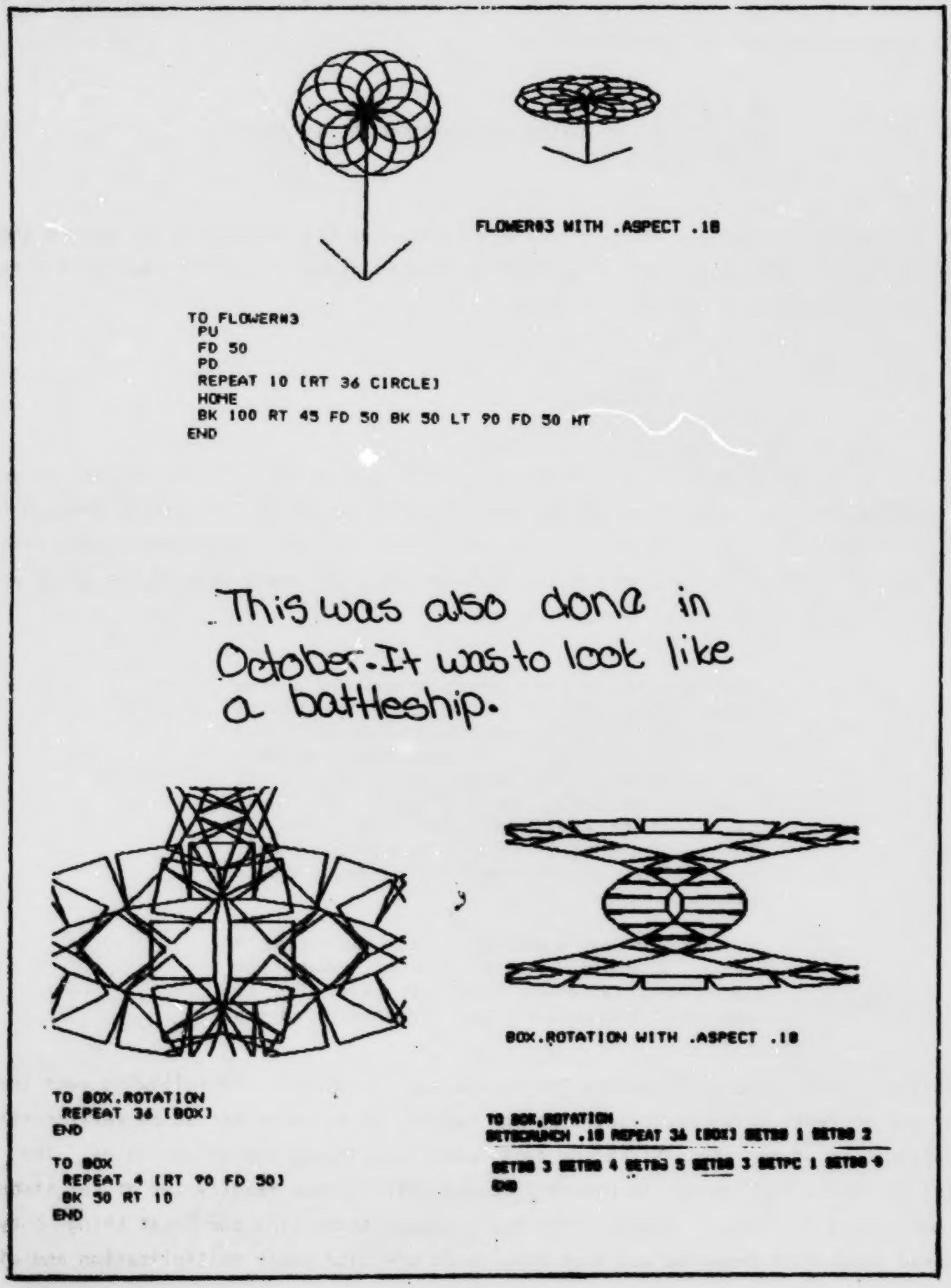
He then wrote a program that flashed these letters on and off at different locations on the screen. SETSCRUNCH was discovered by one junior-level student while browsing through the manual. Students in this class became intrigued by the various effects they could create (Figure 20.7). Another "advanced" concept that was easy for young students to grasp was that of a variable. A primary-level teacher remarked:

> Bobby and Freddy had already programmed a star using REPEAT 5[FD 50 RT 144]. They asked me (last week) if there was a way to do different sizes without retyping. I introduced variable size to them - they told another group. On Friday I got Bobby to explain to the whole class what he and Freddy had done. Now all the class have STAR :SIZE in their Logo books. Bobby also demonstrated it. He changed colours also.
>
> The concept of variable - at the grade 3 level! I would have laughed at anyone who suggested I introduce this last year. Yet it came very naturally upon request. (March 11/83)

This was in a class of so-called "below average" students. The following year this teacher had no reservation about introducing "variables" to her class at an earlier stage. A large proportion of her students became quite competent in the use of variables. The sequence of events highlighted in Figure 20.8 demonstrates how readily two of her students could manipulate variables. However, for the students themselves the "neat thing" they remembered about this sequence was that they could practice their multiplication and division facts while working out the appropriate variable proportions.

Figure 20.7

Examples of Designs That Use the SETSCRUNCH Primitive of LCSI Logo from a Grade 6/7 Class



FLOWER#3 WITH .ASPECT .18

```
TO FLOWER#3
 PU
 FD 50
 PD
 REPEAT 10 [RT 36 CIRCLE]
 HOME
 BK 100 RT 45 FD 50 BK 50 LT 90 FD 50 HT
END
```

This was also done in October. It was to look like a battleship.

BOX.ROTATION WITH .ASPECT .18

```
TO BOX.ROTATION
 REPEAT 36 [BOX]
END

TO BOX
 REPEAT 4 [RT 90 FD 50]
 BK 50 RT 10
END
```

```
TO BOX,ROTATION
SETSCRUNCH .18 REPEAT 36 [BOX] SETBG 1 SETBG 2
 SETBG 3 SETBG 4 SETBG 5 SETBG 3 SETPC 1 SETBG 0
END
```

Figure 20.8

Dialogue Between Two Grade 3 Students and One Of the Researchers While the Students Were Developing a Procedure For a House With Variable Input

Two grade three students, Larry a high- and Andrew an average-achieving student, were drawing a house. When the observer arrived they had already written a procedure for BASE and ROOF but had not tested it yet. They were working on the DOOR.

```
TO DOOR
PC 2 LT 30 BK 50 RT 90 FD 30 LT 90 FD 20 LT 90 FD 20 FD 10 LT 90
END
```

They ran the three procedures at once. "It worked!" They went on to WINDOW.

Andrew was typing:

```
TO WINDOW
RT 180 - "No 270; 270 is three quarters of the way round."
PU FD 30 - "No, 20" prompted Larry.  Andrew patiently explained to him that 20
was the height of the door, therefore 30 was right.  Larry agreed.
PD FD 5 LT 90 FD 5 LT 90 FD 5 LT 90 FD 5 LT 90
```

At this point Andrew said: "Why don't I just use REPEAT?" "I wouldn't do it Andrew", warned Larry in a threatening voice. He did it anyway. The test for both procedures worked! "Want some PC?" asked Andrew. "No, oh yeah". The observer suggested they might add variables as well. They liked the idea.

Very systematically they went about putting :L in the title line of the BASE procedure and then, on Larry's direction, they substituted :L for every FD input. "Let's see", said Andrew as he ran it. It worked and they grinned at each other. They did WINDOW, DOOR and ROOF the same way and put them into a top procedure. When they ran it they were dismayed. Their house was a jumble of squares and a triangle. The observer reassured them that this was only a small problem and through careful questioning led them to see that the initial variable input for HOUSE also determined the length in all other procedures. They were quick to pick up the fact that their original procedures had many different values for FD. They were shown how to use their multiplication and division facts to find the appropriate proportions for :L by using their procedures with fixed input as a starting point and by working backwards from there. After the initial explanation and a couple of examples to illustrate the idea, they happily set out to make the changes. They did so by assuming a basic input of 5 units and proceeded to calculate the corresponding variable inputs. They started to modify the procedure DOOR first:

```
TO DOOR :L
PC 2 LT 30 BK 50 RT 90 Fd :L * 6 LT 90 FD :L * 4 -
```

"No,, this should be 6 because it goes down and is the same as this one (pointing to the long side of the door)". They changed it to 6 and then changed it back to 4. They added the next two terms LT 90 FD :L * 4 END.

Andrew: "What do we do now?"

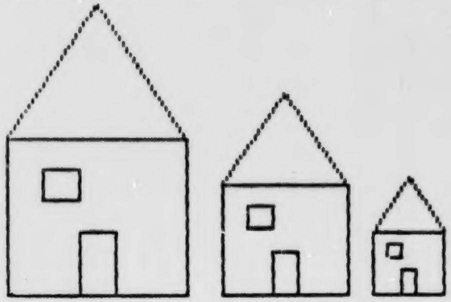
The observer asked if they could run the procedure DOOR. Andrew entered DOOR 25 and saw the square door. "What's going on?". Larry suggested that they not worry about this now and proceed to revise the other procedures first and come back to this later. They changed the base, roof and window. At one point Larry commented: "This is hard, I don't know why we changed it. It worked perfectly before."

They tried out their new house by typing HOUSE 50 - "Oops!". Lines all over the screen, but they knew what was wrong and corrected it with a smaller input: HOUSE 1.

Larry: "It didn't do the roof!"

They edited ROOF and corrected :L to :L * 10. When they ran the HOUSE procedure they saw that there were still a few bugs in it. Their computer time was up, but the results were encouraging enough that they wanted to continue with it another day.

When the observer returned the following week, the boys were eager to share their success and proudly showed her the following picture and procedures:



```
TO HOUSE :L
 BASE :L
 ROOF :L
 DOOR :L
 WINDOW :L
END

TO DOOR :L
 PC 2
 LT 30
 BK :L * 10
 RT 90
 FD :L * 6
 LT 90
 FD :L * 4
 LT 90
 FD :L * 2
 LT 90
 FD :L * 4
END
```

```
TO BASE :L
 PC 4
 REPEAT 4 [FD :L * 10 RT 90]
END

TO ROOF :L
 PC 4
 FD :L * 10
 RT 30
 PC 2 REPEAT 3 [FD :L*10 RT 120]
END
 TU WINDOW :L
  RT 180
  PU
  FD :L * 6
  PD
  PC 3 REPEAT 4 [FD :L * 1 LT 90]
 END
```

Table 25

"What have you learned from working with a computer?"

"What have you learned from working with Logo?"

Responses Pertaining to Mathematics

	Primary	Junior	Intermed.	Total
No. of students sampled	114	84	154	352
Comments	Frequencies			
Mathematics:				
Math, math concepts - non specific	13	15	34	62
Add, sub. multiply, division	19	0	2	21
Timestable: when working with variable house;using Logo's arithmetic functs.	3	3	0	6
Making shapes & geometric designs	25	4	4	33
Angles, degrees, distance on shapes	7	14	21	42
How many degrees in 1/4, 1/2, full circle	2	2	0	4
SETHEADING	2	0	0	2
x-y coordinates, SETXY, SETPOS,graphings	0	7	35	42
Geometry	0	0	11	11
Variables	1	0	7	8
Conditional statements	0	0	4	4
Estimation, measurement	1	1	1	3
Left & right concept	3	0	0	3
Numbers, Value of Numbers	1	1	0	2
Making triangles stick together like a wheel	1	0	0	1
Total	78	47	119	244

Students' own references to mathematics when they were asked as to what they had learned from working with computers/Logo were quite frequent (Table 25). "Math", in a non-specific way, was mentioned most often, and "angles, degrees" and "co-ordinates or graphing" ranked second highest. When students were asked if working with turtle geometry had helped them learn other things more easily, many referred to having gained a better understanding of angles and degrees. The following is a cross-section of their comments:

> Junior:
>
> Before I didn't know my angles; now degrees are easy.
>
> The angle in Logo have helped me in math and geometry.
>
> I have learned the value of numbers. I like to do turns and what all those numbers on a protractor mean.
>
> Intermediate:
>
> I understand angles well after we had worked on computers.
>
> Angles make a lot more sense now. Certainly in geometry; it has helped me grasp the concept and see what the degrees are and not just think in facts, but really understand it.
>
> It gave me a better sense of numbers and bearings.
>
> Understand the angles and dimensions involved in geometrical shapes.
>
> I never knew there were 360 degrees in a circle.
>
> Learning Disability:
>
> The computer has help me with geometry. I was not able to understand geometry.
>
> It has helped the class and myself with patience because you could not just print SQUARE you had to give it angles, length and a lot of time.

On occasion when students lost either a sense of purpose or control, there was evidence that they could lose some of their zest for learning even at the computer. For example, one of the researchers observed the following:

> When James completed his house. he drew a train. It took him quite a long time but he worked well on it until Mr. Veley (the teacher) told him he had to write the procedure down. Robert insisted he had the procedure in his head and did not need to write it down. Mr. Veley would not give in though and as it was a very long procedure I offered to help by writing it down as he told

> me what he had done. He had the whole procedure almost perfectly in his head. Steve was sitting next to Robert and started to draw a train as well ... He also became upset when Mr. Veley said he had to write the procedure down. (Jan. 13/83)

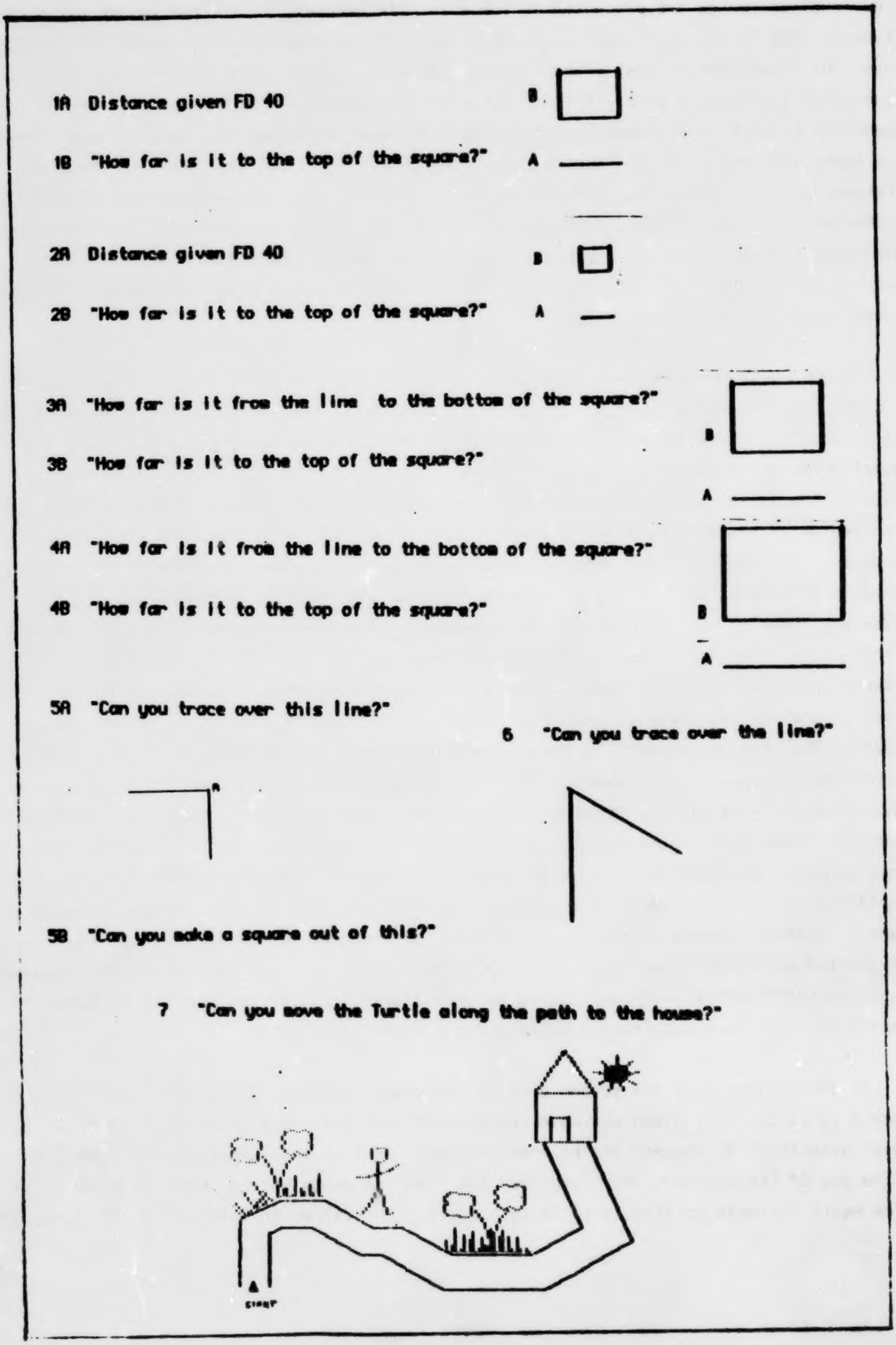
Also, when students were given a turtle geometry quiz at the end of the school year, despite assurances that they weren't expected to know everything on it, some of them became very nervous and inhibited because it aroused typical anxieties of a conventional test. However, certain directions by teachers were necessary and were found to have their place. One intermediate-level teacher observed that:

> Without more direction or guidance students were getting a wrong intuitive sense of factual information. In discussing angles with Charles, for example, I found that he "knew" what angle to give with the RIGHT or LEFT turn instructions in Logo but he assumed that the degrees he put into the computer referred to internal angles instead of the external angle. Charles is a very bright boy but he did not use his other knowledge of acute or obtuse angles to check out what he was doing. By careful questioning I got him to think about this matter and eventually he got onto the "right track". (Dec. 10/82)

In addition to examining the broader implications of exploring with turtle geometry on the mathematics curriculum, this study also attempted to examine in greater detail two properties - distance and direction - fundamental to "turtle" movements. More specifically, it attempted to investigate what effect the extensive use of these concepts has on primary-level students' ability to estimate distance, to know left and right direction from different turtle perspectives, and to estimate angles. In order to assess this effect, at the end of the first year of the study, students from Grades 1, 2, and 3 were shown screen displays of shapes, partial shapes, and pictures on which they were to estimate distances between lines, and to trace partial shapes or to complete them (Figure 20.9). At the beginning of the second year of the study, Grade 1 and Grade 3 students were given one set of these questions (questions 1 to 4) in order to determine their ability to estimate distance without a great deal of exposure to Logo, and Grade 1 students were also given a new question in order to determine their ability to know left and right (Figure 20.11).

Figure 20.9

Computer Portion Of the Logo Quiz Presented to Primary Level Students At the End Of the First Year



1A Distance given FD 40

1B "How far is it to the top of the square?"

2A Distance given FD 40

2B "How far is it to the top of the square?"

3A "How far is it from the line to the bottom of the square?"

3B "How far is it to the top of the square?"

4A "How far is it from the line to the bottom of the square?"

4B "How far is it to the top of the square?"

5A "Can you trace over this line?"

6 "Can you trace over the line?"

5B "Can you make a square out of this?"

7 "Can you move the Turtle along the path to the house?"

In executing question 1(b), approximately 50% of the Grade 1, 80% of the Grade 2, and 48% of the Grade 3 students estimated FD 40 correctly on the first try. The results of the individual estimates are presented in Table 26. In general, of all the values given by students (23% for Grade 1, 48% for Grade 2, and 46% for Grade 3) were correct on the first move. Of those answers that weren't correct on the first try, 10% for Grade 1, 30% for Grade 2, and 35% for Grade 3 were within 10 units of the correct value irrespective of the numerical value of that answer. Estimating a distance of 20 and 40 "turtle steps" created the least difficulty and 60 "turtle steps" (which was 3/2 times the value of the first distance) created the most. Throughout these exercises many students "measured" and estimated with their fingers held against the screen, evaluated, compared, and rechecked. One Grade 2 student, however, entered FD 60 at the appropriate question without much hesitation. When he saw that he was correct he exclaimed with great excitement "Hey, how did I know that? I didn't even know".

Among the Grade 1 students who did not give the correct value on the first try, the majority of adjustments tended to be by small purposeful increments. Others tended to stay with numbers from one to ten and a few students still seemed to be groping without any apparent sense for numbers. Among the Grade 2 and 3 students who did not give the correct value on the first try, a pattern of using adjustments by increments of tens emerged. It appeared as if students were using an estimation algorithm for situations that presented an element of uncertainty. For example, in questions 1 and 2 the first FORWARD 40 distance was given, yet in question 3 the first FORWARD distance was also 40 units but not given to the students. Some of the students who had given correct one step estimates for 40 and 20 turtle units before, used a two step estimation strategy in this situation. The majority of first guesses tended to be on the conservative side. Of all the estimates made, only 13% for the Grade 1, 11% for the Grade 2, and 6% for the Grade 3 students were in excess of the correct answer. This may be inherent in the estimating strategy or there may have been functional reasons for doing so. For example, there was no incentive to take even the slightest risk since students were not specifically asked if they could guess the distance in one move. Also, the lines defining the task to be completed may have presented a psychological barrier since students appeared very concerned about not crossing "the line". For example, in question 5, which required tracing over a line which had no cross line at its end, 86% of the Grade 3 students guessed correctly in one move, as compared to 48% in question 1 which also represented estimating a distance whose value had just previously been given to the students. Mechanical difficulties such as leaving an undesirable trail or not wanting to bother with erasing may also have contributed to choosing a "safe" strategy.

At the beginning of the second year of the study, students in Grade 1 (site 2b) and Grade 3 (site 5b) were given the same questions 1 to 4 that were given to students as a "post" assessment at the end of the previous year. All of the "experienced" Grade 1 students at the end of the previous year surpassed the "new" students who had been in Grade 1 for only a few weeks in their ability to estimate correctly the values in questions 1, 2, 3(a), and

Table 26

Responses to the Following Questions on Estimation from the Logo Quiz for Primary Level Students

1A 2A Distance given FD 40

1B 2B "How far is it to the top of the square?"

3A 4A "How far is it from the line to the bottom of the square?"

3B 4B "How far is it to the top of the square?"

	Site	2a (n - 26)	3a (n - 17)	4a (n - 20)	5a (n - 21)
		Percentages			
Question 1B	No attempts or incomplete	4	6	5	0
	1 try	50	47	80	48
	2 tries	4	12	0	33
	3 tries	4	12	10	19
	Total	58	71	90	100
Question 2B	No attempts or incomplete	8	18	0	0
	1 try	15	6	50	62
	2 tries	12	6	15	38
	3 tries	42	35	20	0
	Total	69	47	89	100
Question 3A	No attempts or incomplete	8	41	5	0
	1 try	42	41	60	57
	2 tries	0	18	20	33
	3 tries	4	0	10	10
	Total	46	59	90	100
Question 3B	No attempts or incomplete	15	36	5	0
	1 try	19	12	20	5
	2 tries	0	12	30	57
	3 tries	27	29	30	28
	Total	46	53	80	95
Question 4A	No attempts or incomplete	31	41	5	0
	1 try	37	41	70	71
	2 tries	12	0	15	19
	3 tries	0	6	10	10
	Total	49	47	95	100
Question 4B	No attempts or incomplete	31	47	5	0
	1 try	12	6	20	33
	2 tries	0	12	20	29
	3 tries	8	18	25	38
	Total	20	36	65	100

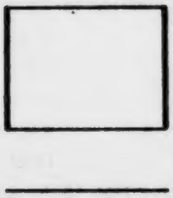


Table 27

A Comparison of the Responses to the Questions on Estimation on the Primary Logo Quiz Given to Students at Sites 2a and 2b at the End of the 1982/3 Year and the Beginning of the 1983/4 Year

Numbers in Percentages

		1982/83		1983/84	
	Site	2a (n-26)	5a (n-21)	2b (n-24)	5b (n- 22)
Question 1.	No attempts or incomplete	4	0	54	0
	1 try	50	48	25	73
	2 tries	4	33	21	18
	3 tries	4	19	0	9
	Total	58	100	46	100
Question 2.	No attempts or incomplete	31	0	67	14
	1 try	12	33	21	50
	2 tries	0	29	4	9
	3 tries	8	38	8	27
	Total	20	100	33	86
Question 3a	No attempts or incomplete	8	0	71	23
	1 try	42	57	4	45
	2 tries	0	33	17	14
	3 tries	4	10	8	18
	Total	46	100	29	77
Question 3b	No attempts or incomplete	8	0	88	27
	1 try	15	62	4	36
	2 tries	12	38	8	27
	3 tries	42	0	0	9
	Total	69	100	12	72
Question 4a	No attempts or incomplete	31	0	21	0
	1 try	37	71	12	87
	2 tries	12	19	21	4
	3 tries	0	10	46	9
	Total	49	100	79	100
Question 4b	No attempts or incomplete	8	0	67	23
	1 try	19	5	8	27
	2 tries	0	57	21	27
	3 tries	27	28	4	23
	Total	46	90	33	77

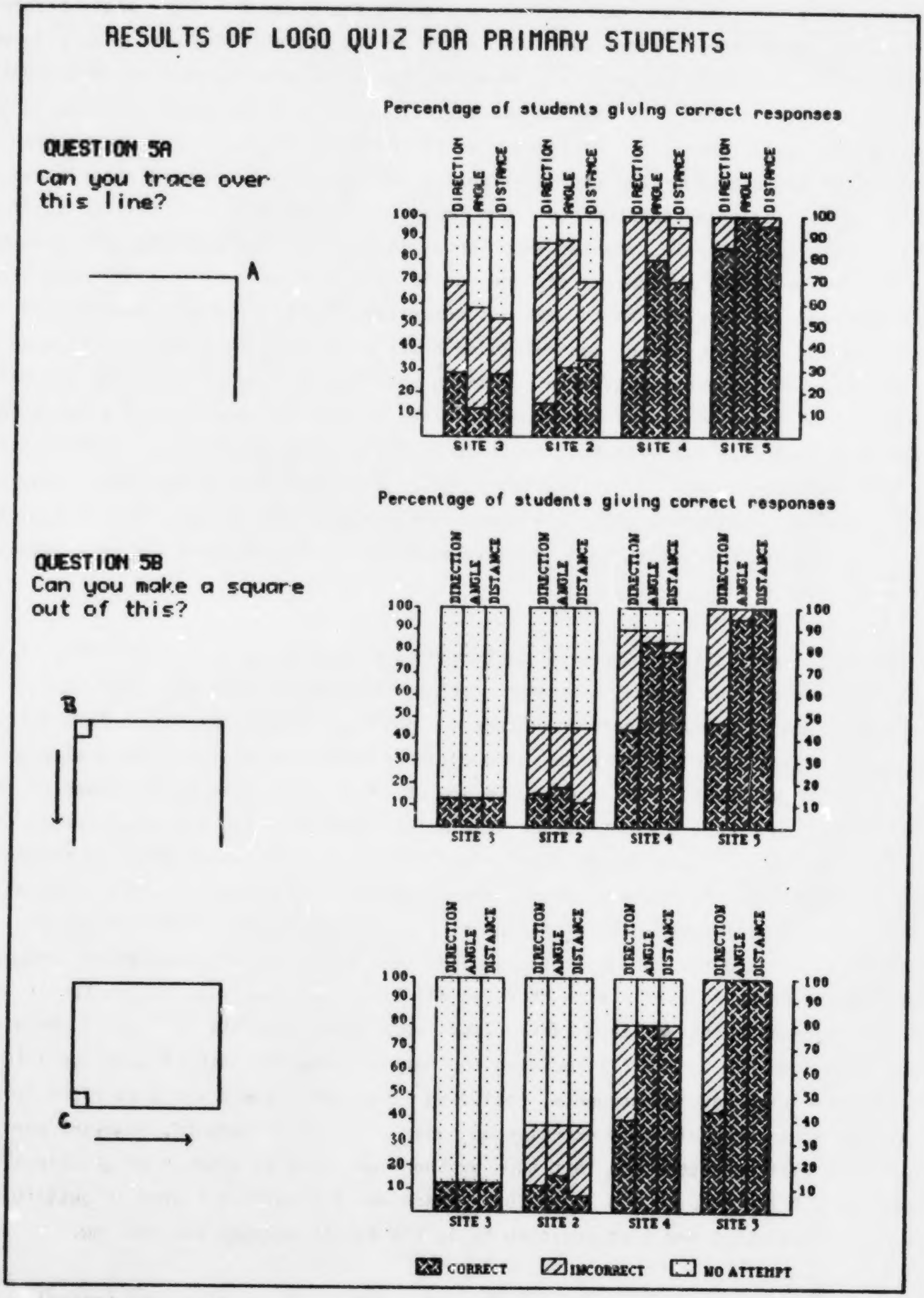
4(a) within two attempts, but in questions 3(b) and 4(b) the younger students surpassed the older students. The overall performance of the new Grade 1 students, however, was still quite impressive (Table 27). These new Grade 1 students had had Logo in Kindergarten during all of the previous year. Among the new Grade 3 students, who had had no prior exposure to Logo the previous year, but who had been using Logo in the class for three weeks before the questions were administered, there were 10% to 28% of the students who were unable to obtain the correct distance within three tries. However, those who gave correct answers surpassed the more experienced students in stating the correct value in their first estimate in all but questions 2 and 3(a) (Table 27). However, when the performance of the two groups was compared on the basis of two-step estimates to the correct value, the more experienced surpassed the less experienced students. One "obvious" explanation for this, as put forth by a teen-ager with considerable computer experience, is that the new students were just trying to come to terms with the parameters of "the turtle" and were very consciously observing the turtle's movements in response to the various numerical inputs. The more experienced students, however, after gaining 'control' over the turtle, were then set free to move on to more interesting and advanced activities. Making specific designs or shapes or exploring the general effect of changing numerical values in a set of instructions or in a program became a more important conscious activity than focusing on the precise dimensions of the length of a line. Under such conditions of exploration a "good" or "efficient" guessing strategy is all that was necessary. Unfortunately, this hypothesis could not be tested since no equivalent post-testing was done (it was decided to administer the junior/intermediate Logo quiz to the Grade 3 students instead).

Based on the analysis of students' performances on questions 5, 6, and 7 (Figure 20.9), students from Grade 1 and Grade 2 were more familiar with RIGHT than with LEFT turns. A greater proportion of students correctly made a right turn (Table 28) than a left turn (question 5a, Figure 20.10). There was also evidence that some students had a strong preference for right turns. For example, in one of the Grade 1 classes, fourteen of the nineteen students who made a right rather than a left turn at point A of question 5a (Figure 20.10), continued to turn the turtle right at all times in question 5b until it pointed in the desired direction. Of these students, seven continued to turn the turtle right at point B and six at point C. The majority of students, if they made a right turn initially, corrected it by turning the turtle left; however, two highly adaptable students, one in Grade 2 and another in Grade 3, used a right turn at all times and simply moved the turtle backwards to accomplish the desired task. There were three students in Grade 1 who did not know what turn commands to use. In guiding the turtle along the path of question 7 (Figure 20.9) there were also several students, including five from Grade 3 who used right turns only. (Grade 3 students did this exercise on paper). Grade 3 students, however, performed almost equally well on either the left turn or the right turn at point A of questions 5a and 6, respectively (Figure 20.10 and Table 28). There was a significant drop in getting the correct turn at points B and C of question 5b as the turtle changed its heading.

At the beginning of the second year, Grade 1 and Grade 3 students were presented with three types of questions in order to assess their ability to identify left and right directions. The first one asked students to raise their left and right arm, the second one

Figure 20.10

Results Obtained from Primary Students on Question 5 of the Logo Quiz (Computer) Portion at the End Of the First Year



asked them to indicate whether an object identified by the researcher was to the right or left of them, and the third asked them to state which way they would have to turn as they pretended to move along a path that was presented to them on the computer screen (Figure 20.11). Although it was not possible to collect the appropriate post-results, it is still worth noting that 67% or more of the Grade 1 students were able to give the correct answers to all but two questions: pointing to an object on their right (58%), and making the last left turn on the path (50%). Of the Grade 3 students 82% or more were able to give correct answers to all but the last left turn on the path (68%) (Table 29).

The ability to estimate angles also varied among students. 12% of students in one Grade 1 class, and 31% of students in the second Grade 1 class correctly identified the 90 degrees turn at point A of question 5a (Figure 20.10). This proportion increased to 80% for Grade 2 students, and to 100% for Grade 3 students. In estimating the turn at point A of question 6 (Table 28), students ran into a great deal of difficulty because of the shape of the turtle. The turtle alone, as it is presently constructed in Terrapin and LCSI Logo, is not a good medium for developing a numeric sense for the size of turns. Students found it extremely difficult to see which way the turtle was facing. They would often stop and puzzle which way the turtle was pointing because the point of the turtle disappeared quite quickly when the turtle turned in increments of less than 90 degrees. In order to get a visual sense of the size or direction of the turn (or degree), the turtle had to make a line which required a direction input. There was no obvious immediate feedback in direct response to a LT or RT input.

Throughout these exercises, many Grade 1 students showed a preference for certain numbers. This became particularly evident when students in one Grade 1 class were asked to walk the turtle along the path (see question 7, Figure 20.9). Three students, for example, used RT 45 at all times, no matter what the question was. Others liked the number 12: for example, one student used thirty-two 12's in combination of LT, RT, FD and BK. When she was asked why she used the number 12 she replied that "Mrs. North (her teacher) said to use 12 if it's curvy or hard". (Mrs. North had no recollection of ever having said such a thing). One student who used twenty 12's FD, LT, or RT said "I use 12 all the time because it makes it go just a bit and I can see where it is going". Another student, who had used six consecutive 12's, changed to the sequence RT 190 FD 19 FD 50 RT 1209 FD 100 without any apparent sense of the numbers typed. Several students made extensive use of the number 34; some young students used only numbers between 1 and 10 and often moved only one increment at a time. One student used only the numbers 1, 2, 3, and 4 either singly or in combinations. There were other students who used larger numbers, such as: 89 12 31 60 1 20 23 12 23 39 39 12 39 39 12 32 20 20 42 23 21 32 32 29, who were aware of these numbers as a unit rather than small numbers side by side. Although students were developing a sense of bigger or smaller, and playing with large numbers, some students did not connect numeric values with such relationships. For example, one student was able to move the turtle in one of the estimation questions exactly 40 units by small increments. She was told that all "these numbers" added up to 40 and then asked whether the next distance was bigger or smaller. She correctly replied "bigger" but then entered FD 9 and continued to proceed with small increments.

Table 28

Responses to Question 6 from the Logo Quiz for Primary Students

"Can you trace over the blue line?"

Site	2a (n=26)	3a (n=17)	4a (n=20)	5a (n=21)
		Percentages		
No attempt	31	42	10	0
Direction RT	69	35	75	90
Angle 120	4	0	10	24
Distance 80	15	12	65	86

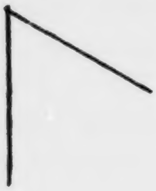


Figure 20.11

Picture of a Shape Presented on the Computer to Primary Students At the Beginning of the Second Year to Assess Their Command Of the Concept 'Left' and 'Right'

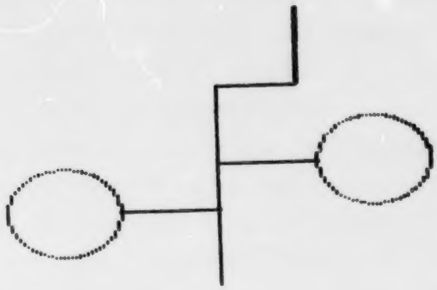


Table 29

Results of Pre-Test Given to Grade 1 Students at Site 2b to Assess their Left and Right Skills, Based on Figure 20.11

Site	2b (n=24)	5b (n=22)
	Percentages	
Left arm	67	95
Right arm	67	95
Left object	67	82
Right object	58	95
Visual left circle	79	82
right circle	79	82
Path left circle	67	95
right circle	71	95
right turn	71	86
left turn	50	68

There was evidence that many students did not automatically transfer knowledge or facts gained in one medium or situation to another. It appeared that repetitive behaviour alone did not guarantee the eventual acquisition of conscious knowledge of a given fact. The results of the Logo quiz, for example, showed that many students still had difficulties making a correct sketch of a given set of sequential "turtle commands" that was to have drawn a triangle (question 3a in Table 37, Appendix A); and 40% of the junior-level students who had explored extensively with Logo for one year, but with little direction from the teacher, still were unable to give either the correct number of repeats, or the correct size of the angle for making a square in turtle geometry (question 2a in Table 36 - Appendix A) - even though these students had used triangles and squares in their graphic explorations. The questions dealing with the pentagon and octagon (question 2b and 2c in Table 36 - Appendix A) were intended to examine whether, after making many shapes, students might have learned about the "total turtle trip theorem", and, hence, might be able to calculate the correct angle for these shapes. At most, 38% of students (site 9a) were able to give the correct instructions. Surprisingly, these students had had little time with turtle geometry but were among the oldest (Grade 8) students in the study. Situations or questions that caused students to stop and question what they were doing were often instrumental in guiding students into becoming more reflective about specific details of their activities. For example, one of the researchers reported the following interaction in her logbook:

> Ingrid (a grade three student) rotated a rectangle one turtle turn at a time, 540 times and produced a circle that was filled in. When I asked her if it had gone over part of the circle again she said "yes", thought for a minute and then said, "I bet 360 degrees would do it. I'm going to try it. (Feb. 10/84)

21. ORAL COMMUNICATION

The high degree of social and intellectual interaction at and around the computer gave students an excellent focus for developing a wide range of listening and speaking skills, as outlined in The Formative Years (Figure 21.1). The following objective was particularly relevant:

> [To develop] vocabulary that enables him or her to name, describe, reason, explain, and use qualitative words as he or she plays, observes, manipulates, creates, and experiments with stimulating materials. (page 8)

All of these components, as well as the use of quantitative words, came into play as students discussed their computer activities among themselves, or as they made up stories about the drawing they were generating on the screen. In working towards a common goal, students working in pairs became much more sensitive to a need for expressing their ideas clearly and for critically listening to others' ideas. This became particularly evident when disagreement arose. An example of a fifteen minute exchange between two Grade 3 students is given in Figure 21.2. It is a lighthearted, yet serious, exchange between two boys who learned to "give and take" and who not only learned to get along but also, as one of them said: "we fight good". The immediate focus of a commonly shared activity made it much easier for some students to engage in speaking to other students. For example,

> [Grade 3] Craig showed a house he had done and explained in detail how he had put in the doors and window. This was really good for Craig. He doesn't shine in very many things. The children paid him a lot of attention. Very good for Craig's self image. (Nov. 21/83)

> [Intermediate] Karl and Ian are working on an adventure game. ... Ian really surprised me today. He is usually very quiet and unsure of himself, but when talking about this adventure world he is excited and animated and expresses himself very well. These boys are totally rapt in this activity and their intensity is fierce. (March 20/84)

Students also learned to express themselves clearly, and to listen and react to questions as they acted as consultants to other students in the class. Further experience was acquired when they were teachers to students and teachers in other grades. In addition, students had an opportunity to engage in dialogue with their own teacher, with visitors to the classroom, and with strangers at computer fairs that were held at school or in shopping centres. As students gained greater control over their speaking skills and greater insight into their problem-solving methods, their skills in expressing their ideas were also sharpened. For example, a junior-level teacher reported:

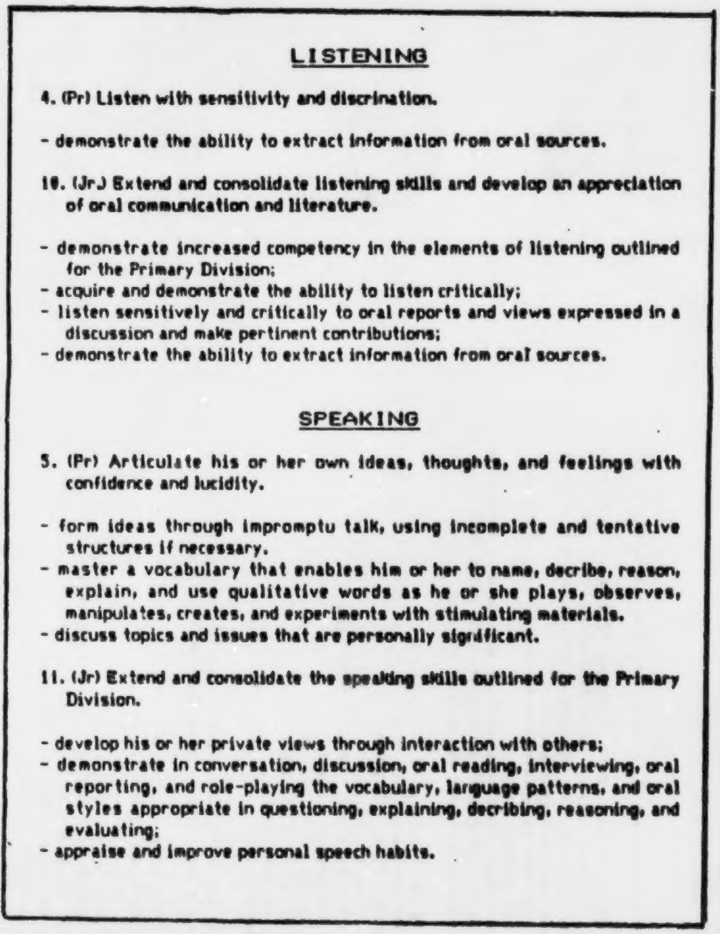
> Sharing time is taking on more of a peer teaching quality rather than just a showing off session. (Jan. 21/83)

Social interaction near the computer was both more spontaneous and more extensive than it was in other parts of the classroom. One junior/intermediate-level teacher felt that this interaction was not only desirable for developing social, speaking or listening skills, but were necessary to sustain motivation and to encourage students to explore more deeply. He stated that:

> If discussions, group interactions, were removed, I suspect the excitement would die and a student would not look as deeply into a problem. Problems on the computer seem to be infectious. Other pupils quickly gather to offer support and suggest alternative methods of solving the problem. (Dec. 1/82)

Figure 21.1

An Extract From "The Formative Years" Showing the Specific Topics in 'Listening' and 'Speaking' That Came Into Play While Students Worked at the Computer And Presented Their Work to Others



LISTENING

4. (Pr) Listen with sensitivity and discrination.

- demonstrate the ability to extract information from oral sources.

10. (Jr.) Extend and consolidate listening skills and develop an appreciation of oral communication and literature.

- demonstrate increased competency in the elements of listening outlined for the Primary Division;
- acquire and demonstrate the ability to listen critically;
- listen sensitively and critically to oral reports and views expressed in a discussion and make pertinent contributions;
- demonstrate the ability to extract information from oral sources.

SPEAKING

5. (Pr) Articulate his or her own ideas, thoughts, and feelings with confidence and lucidity.

- form ideas through impromptu talk, using incomplete and tentative structures if necessary.
- master a vocabulary that enables him or her to name, decribe, reason, explain, and use qualitative words as he or she plays, observes, manipulates, creates, and experiments with stimulating materials.
- discuss topics and issues that are personally significant.

11. (Jr) Extend and consolidate the speaking skills outlined for the Primary Division.

- develop his or her private views through interaction with others;
- demonstrate in conversation, discussion, oral reading, interviewing, oral reporting, and role-playing the vocabulary, language patterns, and oral styles appropriate in questioning, explaining, decribing, reasoning, and evaluating;
- appraise and improve personal speech habits.

Figure 21.2

An Example of a Typical Interaction Between Two Grade 3 Students as They Worked Together at the Computer

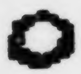
Karl and John, two grade 3 students, wrote a procedure called HITJOHN :L.
REPEAT 12 [FD :L RT 65 PC 5 FD :L RT 56] PC 6 FD :L RT 45 PC 4 FD :L RT 65 FD :L RT 65 PC 3 FD :L PC 2 RT 65 FD :L END.
The observer asked if they knew what the instructions would draw.
Karl: "No we are just experimenting."
Observer: "Why have you chosen these numbers?" (pointing at various angle values)
Karl : "No reason, just experimenting and see what will happen."
They ran the following instructions stopping after each step to observe the outcome before deciding on the next step.

HITJOHN 6 FD 43 HITJOHN 6 FD 45 HITJOHN 6
John: "It will probably join in a circle, at least I hope so."
FD 45 HITJOHN 6 FD 45 HITJOHN 6
John: "No, it didn't do it."
FD 45 HITJOHN 5 FD 45 HITJOHN 6 FD 45 HITJOHN 6
John: "Are you making a star?"
Karl let John type:
FD 45 HITJOHN 6 FD 45 HITJOHN 6
John: "Now you have a star."
Karl: "Neat-O"

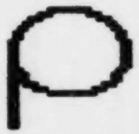
Karl set PU and moved the Turtle to another part of the screen.
John: "You are not going to do another one." (in a warning voice)
Karl: "Yes!"
John: "Oh, its going to take too long."
Karl: "I'll let you do it."
John: "Ok."
Karl: "HITJOHN 10."
John experimented with adding five more sequences of HITJOHN 6 FD 45 then Karl typed again. John was bored, played with the typewriter keys and moved his feet alot.
Karl: "Oh it didn't join."
John: "Yes it did."
Karl: "Yah, sort of."
Karl finished the ten circled star. "Freaky eh?" he said bringing it to the attention of a boy nearby. John and Karl struggled over who would do the typing to save the picture. They weren't going to save the procedure but the observer asked them to.

Karl: Our time isn't up yet."
John: I"ll now make a procedure HITKARL."
Karl: "Don"t make it too long."
Karl began to read Logo command charts while John was typing. He ran the procedure, a rectangle.
Karl: "Neat-O, make a ty-fighter."

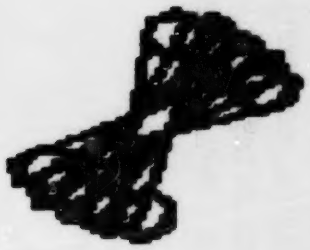
HITJOHN 6



HITKARL



"Now you have a star."



TO HITKARL
FD 20 REPEAT 36[FD 2 RT 10] REPEAT 36[FD 2 RT 10] END
Karl: "Yeah, freaky, lets make it shoot."
REPEAT 45[FD 50 DRAW]
John: "This will make it shoot!" (picture disappeared and returned)

REPEAT 10[FD 20 HITKARL]
Karl: "Neat!! It's a crossword puzzle. Do it again."
John typed:
REPEAT 10[FD 20 HITKARL] REPEAT 20[FD 20 HITKARL FD 20 HITKARL]

They changed background colour several times, and changed the intensity of colour using the monitor button. They scuffled over the keyboard. Karl couldn't finish his instructions and John pushed RETURN. They got a straight line and both laughed.
Karl: "REPEAT 10[FD 20 HITMARK]
John: "I don't want to hit Karl. He is my best friend."
Karl typed in different BG colours while the turtle was executing. He didn't realize the computer couldn't recognize instructions. He did it often enough that that BG 6 coincided with the execution of the procedure and he got a result. They saved their procedure and Karl typed GOODBYE. They weren't concerned that they lost their procedure. "Oh, it doesn't matter."

22. READING AND LANGUAGE ARTS

Computer activities encouraged reading both directly and indirectly. A summary of the corresponding reading objectives, as outlined in The Formative Years, is given in Figure 22.7. The Logo language - its primitives, grammar, and the error messages - offered continuous opportunities to respond to printed stimuli. Error messages such as TELL ME HOW TO DRAW, led even Grade 1 students to take appropriate action when they appeared on the screen. One Grade 2 teacher reported that:

> The children are reading the error messages more closely. At first they simply came to the conclusion that because there was a number of words on the screen they had made a mistake, but some now try to make use of them to correct their work. (May 12/83) .

Students had additional opportunities as they created and named procedures. Several teachers commented that the computer was a strong motivating force for engaging students in reading:

> [Kindergarten] Some alphabet recognition is required to make the turtle move. The incentive is there to master these letters. (May 12/83)
>
> [Emotional Adjustment Class] Students tend to be able to decipher words given in response by the computer with much more accuracy when working on the computer than if reading elsewhere. ... The necessity of knowing how to read given instructions in order to follow the steps is a good learning aid. Words which might otherwise seem impossible to learn or unnecessary are given more attention. (May/83)
>
> [Learning Disability Class] Learning a new language and constant repetition of terms most definitely served as an aid to some of the children in the language arts area - we had use of a few programmed disks that entailed reading that most were able to get through quite well. .... Reading is extremely difficult for many of these children, therefore, readers and comprehension exercises are not exactly exciting companions for them. The computer is something they all thoroughly enjoyed and any concept to be learned through it seemed to be attained more easily. (June 20/83)

While creating procedures, students needed to read their instructions with precision, especially when they encountered a mistake. Interactive quizzes and stories, which always created great excitement among students of all grades, offered a good opportunity for students to read and examine words and sentences for content and meaning as they responded to the cues or questions. Humour was often an integral part of such activities. For many students, the computer generated an interest in reading books, articles, magazines, and manuals about computers. The opportunity and desire to share their knowledge provided a strong incentive to do so.

The printed output, generated either through Logo or a word processor, also facilitated reading. Students, particularly those in the primary-grades, found it easier to read the printed writing than their own handwriting. Proof-reading became important in those classes where word processing was used extensively. Even if the teacher did the initial proof-reading, students still needed to re-read their stories as they made the necessary corrections. An entry in a researcher's logbook described the following scene during her visit to a junior-level class:

> They edited Susan's story first. Linda read out Mrs. Cook's corrections and Susan typed them in. When they finished they changed places and Susan read the corrections while Linda typed them in. (Oct. 21/83)

Further reading occurred when Grade 1 students were asked to copy or to use words or sentences from "worksheets" that the teacher had placed by the computer. Two teachers in this study created additional opportunities for reading by encouraging students to read their stories about computers, or produced on the computer, to each other, or to students outside their classroom.

The writing process was also greatly facilitated by using the computer (a summary of writing objectives as outlined in The Formative Years, is given in Figure 22.8). Primary and junior-level students enjoyed using the keyboard. They "hunted" for the appropriate keys with amazing patience which was often preferable to the difficult task of writing by hand. This was not the case for intermediate-level students since their writing skills were already well developed. For them the lack of keyboard skills was an annoyance. Everyone, however, appreciated getting a neat-looking copy of their writing. A Grade 1, a Grade 3, and a Grade 5 teacher made extensive use of the computers in their language development program. The Grade 1 teacher used computers for letter recognition, for improving vocabulary, and for writing individual and group stories. Students were encouraged to print letters or words that started with a given letter. They were also free to work at their own level and to increase their explorations as their own desires or needs dictated. Several students took charge of their own learning. For example:

> Didi and Susie (two Grade 1 students) sat at the keyboard as Didi typed in several rows of the letter D. Then the two girls turned to a textbook, looking for words that started with

> D and typed them into the computer. When the screen was full, Didi typed in the commands to start the printer reached for a printout and read it. (Nov. 24/83)

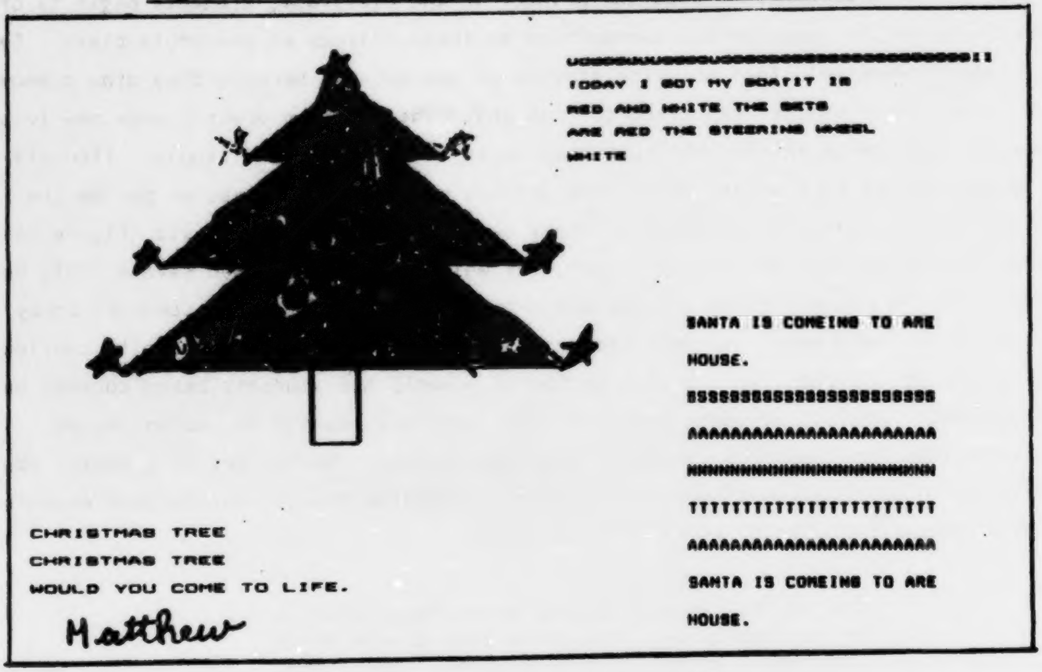
Others copied from a set of words that the teacher had placed by the computer. Since it was now easy to produce "worksheets" with the printer in the classroom, students began to create such worksheets on the computer and handed them to their friends or the whole class. Several Grade 1 students were reluctant to write stories at the outset, because they didn't know how to spell. When their teacher explained to them that "the computer doesn't know how to spell either so you can use invented spelling", they began to write more willingly. Students were free to write stories with words chosen from various cards that the teacher put by the computer (Figure 22.1), or to write about their own activities and interests (Figure 22.2). The teacher also organized an "Author's Tea", for which students created several "Big Books", which represented a collection of stories and artwork done either on the computer or by hand. In preparation for the event, students produced a recipe book of their favourite cookies by printing it out on the computer. Over a period of a week, the students baked cookies based on these recipes. Invitations were sent out to parents and, during the actual event, students were asked to read from the books they had created. One of the "Big Books" was made into a film strip and "released" for the occasion. Creative thought was further encouraged through oral compositions that led to a "class" story:

> The teacher read a series of Mr. Mugs stories to the children. The class was then divided into small groups of 3-4 children. Each group composed one page which was typed into the Logo editor by the teacher. The first group wrote page 1. It was then read to the class and the second group of children wrote page 2. Pages 1 and 2 were then read to the class and group 3 wrote page 3, and so on. Every student got a copy of each page as it was completed. Students then illustrated them individually and created their own personalized book of Mr. Mug's Adventures.

A copy of one of the "books" appears in Figures 22.3, 22.4, and 22.5. The emphasis on using the keyboard for writing did not keep students from practicing their handwriting. Students quite readily used their computer output for further handwritten comments or illustrations.

Figure 22.1

Examples of Writing by Grade 1 Students That Made Use Of Words Set Out On Cards By the Teacher; Produced on the Logo Editor and Printed out with the PRINTIT Procedure



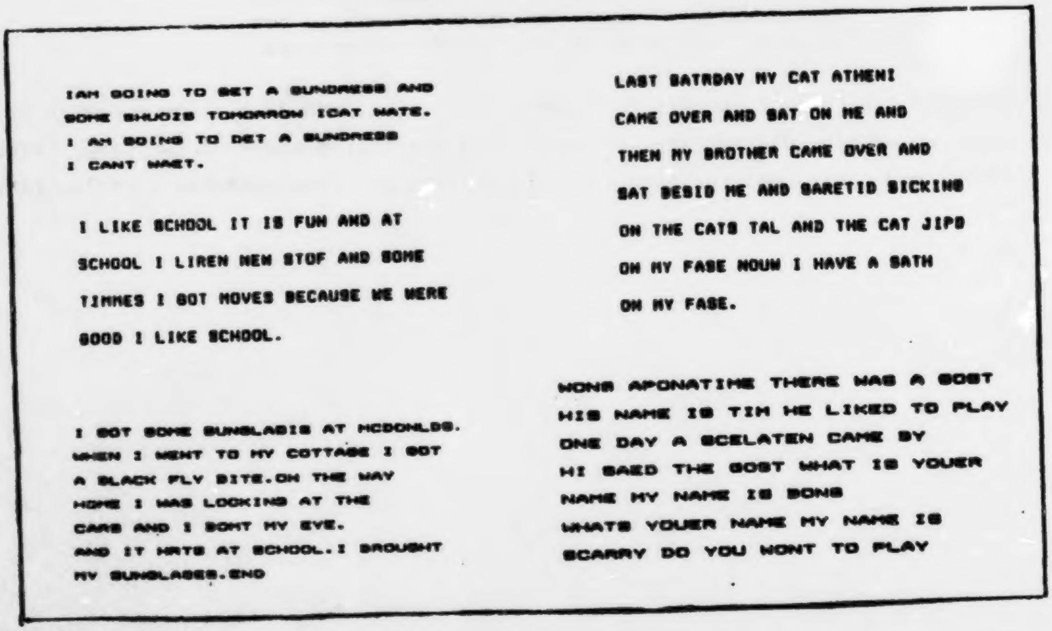
[illegible]
TODAY I GOT MY GOATIT IS
RED AND WHITE THE SETS
ARE RED THE STEERING WHEEL
WHITE

SANTA IS COMEING TO ARE
HOUSE.
SSSSSSSSSSSSSSSSSSSSSSS
AAAAAAAAAAAAAAAAAAAAAAA
NNNNNNNNNNNNNNNNNNNNNNN
TTTTTTTTTTTTTTTTTTTTTTT
AAAAAAAAAAAAAAAAAAAAAAA
SANTA IS COMEING TO ARE
HOUSE.

CHRISTMAS TREE
CHRISTMAS TREE
WOULD YOU COME TO LIFE.
Matthew

Figure 22.2

Examples of Non-Directed Writing by Grade 1 Students Using the Logo Editor



IAM GOING TO GET A SUNDRESS AND
SOME SHUOIS TOMORROW ICAT WATE.
I AM GOING TO DET A SUNDRESS
I CANT WAET.

I LIKE SCHOOL IT IS FUN AND AT
SCHOOL I LIREN NEW STOF AND SOME
TIMMES I GOT MOVES BECAUSE WE WERE
GOOD I LIKE SCHOOL.

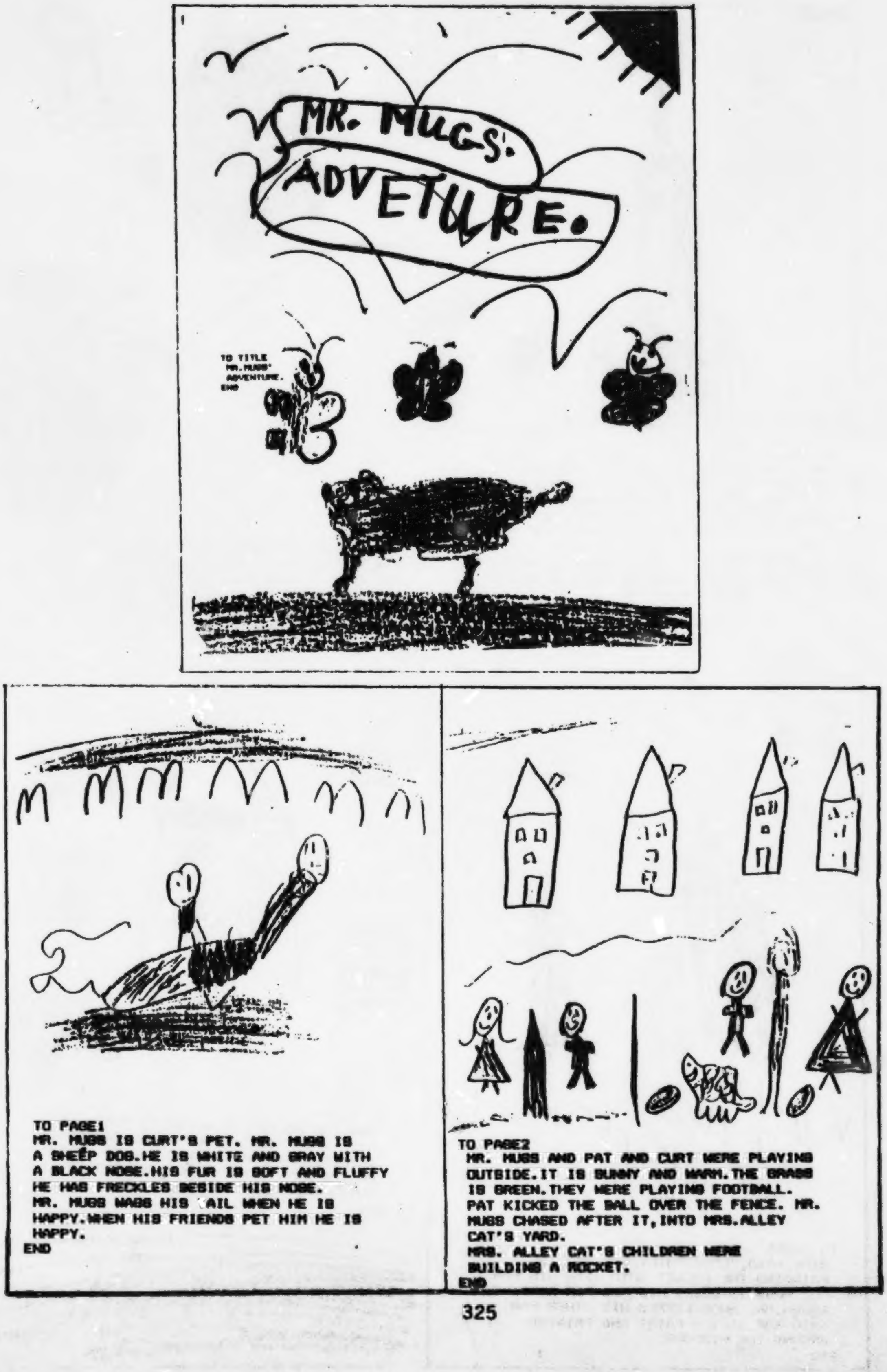
I GOT SOME SUNGLASIS AT MCDONLDS.
WHEN I WENT TO MY COTTAGE I GOT
A BLACK FLY BITE.ON THE WAY
HOME I WAS LOOKING AT THE
CARS AND I SOHT MY EYE.
AND IT HRTS AT SCHOOL.I BROUGHT
MY SUNGLASES.END

LAST SATRDAY MY CAT ATHENI
CAME OVER AND SAT ON ME AND
THEN MY BROTHER CAME OVER AND
SAT BESID ME AND SARETID SICKING
ON THE CATS TAL AND THE CAT JIPD
ON MY FASE NOUW I HAVE A SATH
ON MY FASE.

WONS APONATIME THERE WAS A GOST
HIS NAME IS TIM HE LIKED TO PLAY
ONE DAY A SCELATEN CAME BY
HI SAED THE GOST WHAT IS YOUER
NAME MY NAME IS BONS
WHATS YOUER NAME MY NAME IS
SCARRY DO YOU WONT TO PLAY

Figure 22.3

'Mr. Mugs Adventure': A Class Story Created by Grade 1 Students; Pages 1, 2, and 3



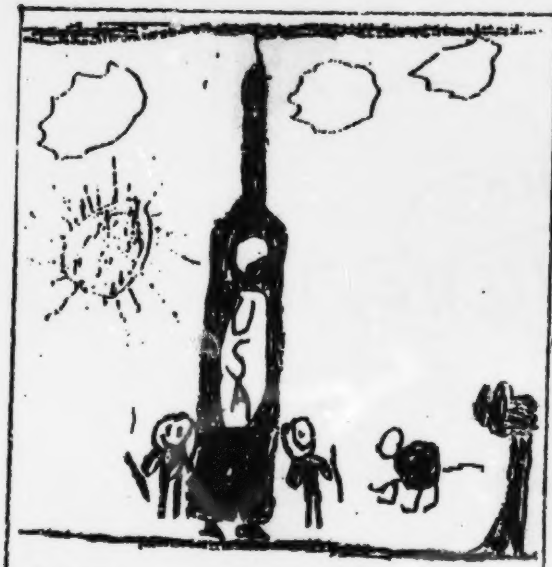
TO TITLE
MR. MUGS'
ADVENTURE.
END

TO PAGE1
MR. MUGS IS CURT'S PET. MR. MUGS IS
A SHEEP DOG.HE IS WHITE AND GRAY WITH
A BLACK NOSE.HIS FUR IS SOFT AND FLUFFY
HE HAS FRECKLES BESIDE HIS NOSE.
MR. MUGS WAGS HIS TAIL WHEN HE IS
HAPPY.WHEN HIS FRIENDS PET HIM HE IS
HAPPY.
END

TO PAGE2
MR. MUGS AND PAT AND CURT WERE PLAYING
OUTSIDE.IT IS SUNNY AND WARM.THE GRASS
IS GREEN.THEY WERE PLAYING FOOTBALL.
PAT KICKED THE BALL OVER THE FENCE. MR.
MUGS CHASED AFTER IT,INTO MRS.ALLEY
CAT'S YARD.
MRS. ALLEY CAT'S CHILDREN WERE
BUILDING A ROCKET.
END

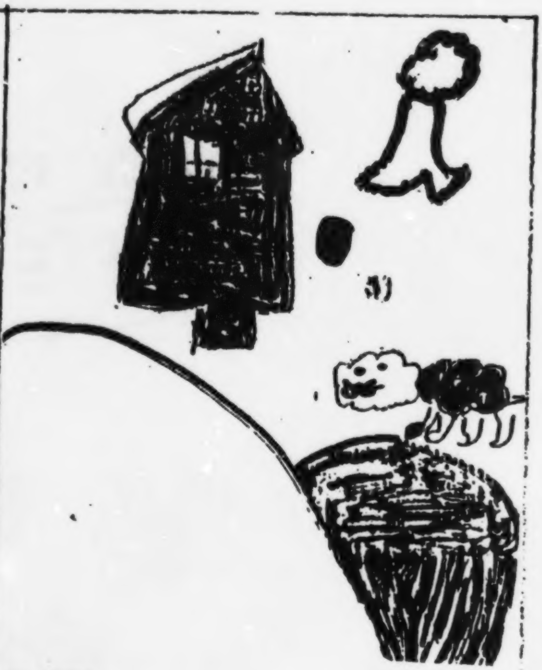
Figure 22.4

'Mr. Mugs Adventure': A Class Story Created by Grade 1 Students; Pages 3, 4, 5, and 6

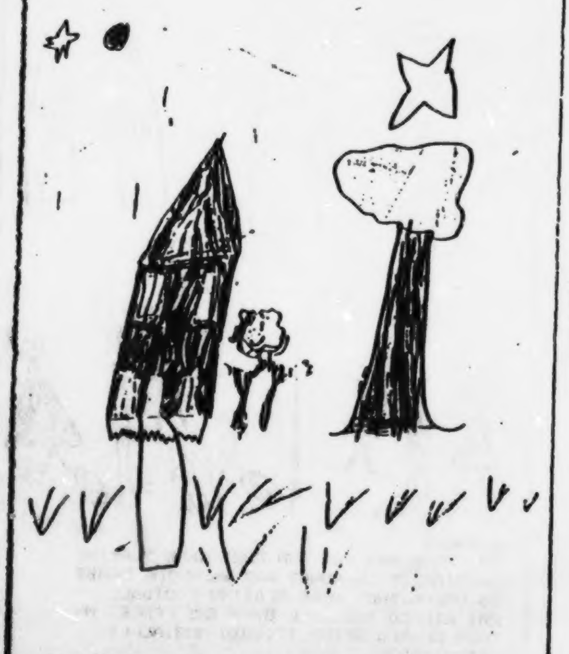


TO PAGE3
MR. MUGS FORGOT ABOUT THE FOOTBALL. HE WAS MORE INTERESTED IN THE ROCKET. MIKE AND EMILY WERE BUILDING A ROCKET AND A BIG,HUGE DOG CAME BOUNDING INTO THEIR YARD. EMILY SAID "WHOSE DOG ARE YOU".

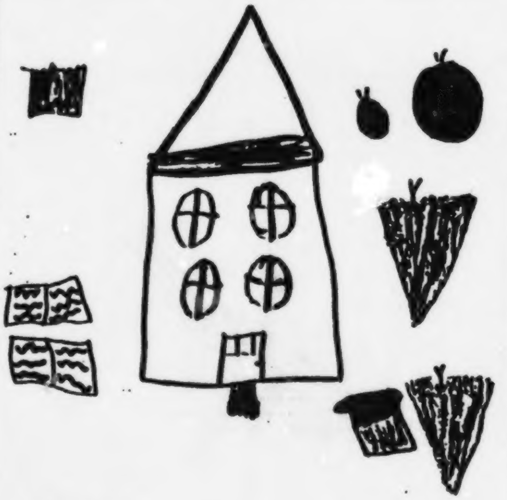
MR. MUGS BARKED A FRIENDLY BARK BECAUSE HE DIDN'T WANT TO SCARE THEM.HE WANTED TO MAKE THE ROCKET TOO.
END



TO PAGE4
THE ROCKET WAS MADE OUT OF WOOD.IT HAD SIX WINDOWS MADE OUT OF CARDBOARD. MR. MUGS WANTED TO PAINT THE ROCKET.HE SAW SOME POTS OF SILVER AND PINK PAINT BESIDE THE ROCKET.MR. MUGS DIPPED HIS PAW INTO THE PINK PAINT AND BEGAN PAINTING THE ROCKET SHIP.
END



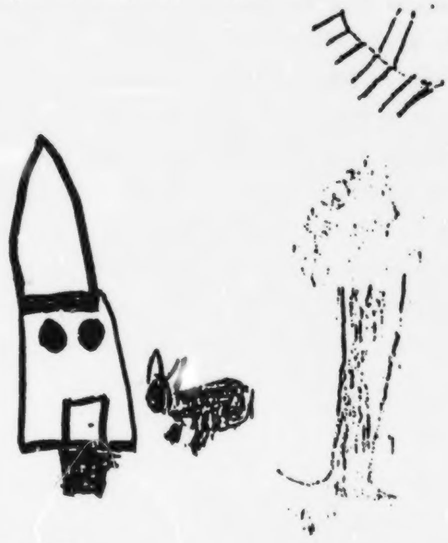
TO PAGE5
MIKE SAID,"LOOK EMILY,THE DOG IS PAINTING THE ROCKET SHIP WITH HIS PAW". MR. MUGS IS USING HIS PAW FUR A PAINT BRUSH.MR. MUGS DIPPED HIS OTHER PAW INTO THE SILVER PAINT AND PAINTED AROUND THE WINDOWS.
END



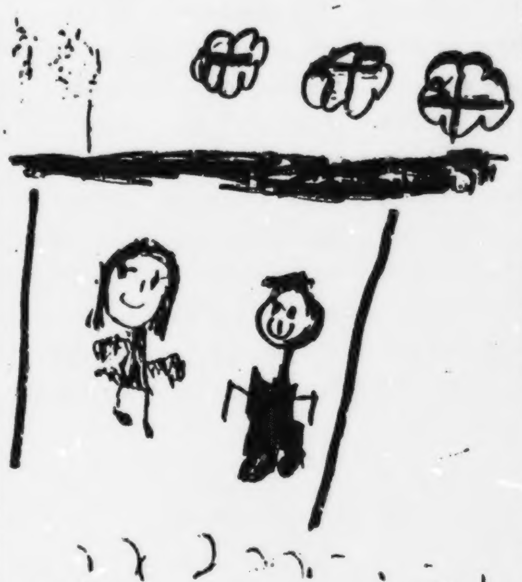
TO PAGE6
NOW THE ROCKET IS READY TO BLAST OFF. MIKE AND EMILY BROUGHT SOME CARROTS, APPLES,BRAN MUFFINS AND CHEESE TO EAT ON THE WAY TO MARS.THEY BROUGHT SPACE SUITS AND SOME BOOKS TO READ.
END

Figure 22.5

'Mr. Mugs Adventure': A Class Story Created by Grade 1 Students; Pages 7, 8, 9, and 10

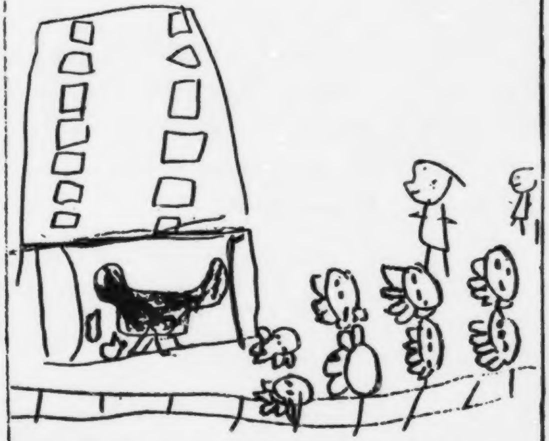


TO PAGE7
THE CHILDREN INVITED MR. MUGS TO GO ON
THE TRIP. EMILY SAID, "GET IN THE ROCKET
MR. MUGS".
MR. MUGS RAN AWAY. HE RAN OUT OF THE
YARD AND DOWN THE STREET. HE SAW A
GARBAGE CAN. MR. MUGS JUMPED INTO THE
CAN TO HIDE HE WAS SCARED.
END



TO PAGE8
MEANWHILE PAT AND CURT WERE WAITING
FOR MR. MUGS TO RETURN WITH THE
FOOTBALL. THEY HAD BEEN WAITING A LONG
TIME. THEY WERE WORRIED ABOUT MR. MUGS.
THEY DECIDED TO GO AND LOOK FOR HIM.
END

TO PAGE9
THEY SET OFF DOWN THE STREET. AS THEY
WENT FURTHER DOWN THE STREET CURT SAID,
"LOOK PAT, THERE ARE PINK AND SILVER
PAWMARKS, MAYBE THEY BELONG TO MR. MUGS.
LET'S FOLLOW THEM".
END



TO PAGE10
THE PAWMARKS LED TO THE GARBAGE CAN.
WHEN THEY LOOKED INSIDE THEY SAW MR.
MUGS CRYING AND SHAKING. THEY PULLED
HIM OUT AND HUGGED AND KISSED HIM.
MR. MUGS, HOW DID YOU GET PINK AND
SILVER PAWS?
MAYBE HE HAD AN ADVENTURE.
WHAT DO YOU THINK OF THAT?
END

Grade 3 and Grade 5 students made extensive use of the Bank Street Writer word processor. In addition, writing activities were extended and themes and contents of their writings became more immediate as students wrote about their computer activities in their journals, in letters to penpals, or as they commented on the designs or pictures before they printed them out. The teachers in these two classes and a Grade 7 teacher also capitalized on their students' interest in Logo by turning the screen turtle into a living entity that went on a series of adventures. A Grade 5 and 7 class wrote stories about how the turtle got into the computer (Figure 22.6). Grade 3 students wrote stories about the "turtle". The junior-level students called the screen turtle "Appledumpling" - which became the focus of a series of stories: "How Appledumpling Got Inside the Computer", "Appledumpling's Adventures in the Computer", "Appledumpling Meets Pacman", and "Appledumpling Meets Team Canada". The students in that class also wrote puppet plays which were related to the adventures of Appledumpling and the scripts were peppered with computer terminology. The teachers were very excited about the impact the computer had on their students' writing program. A junior-level teacher made the following observation:

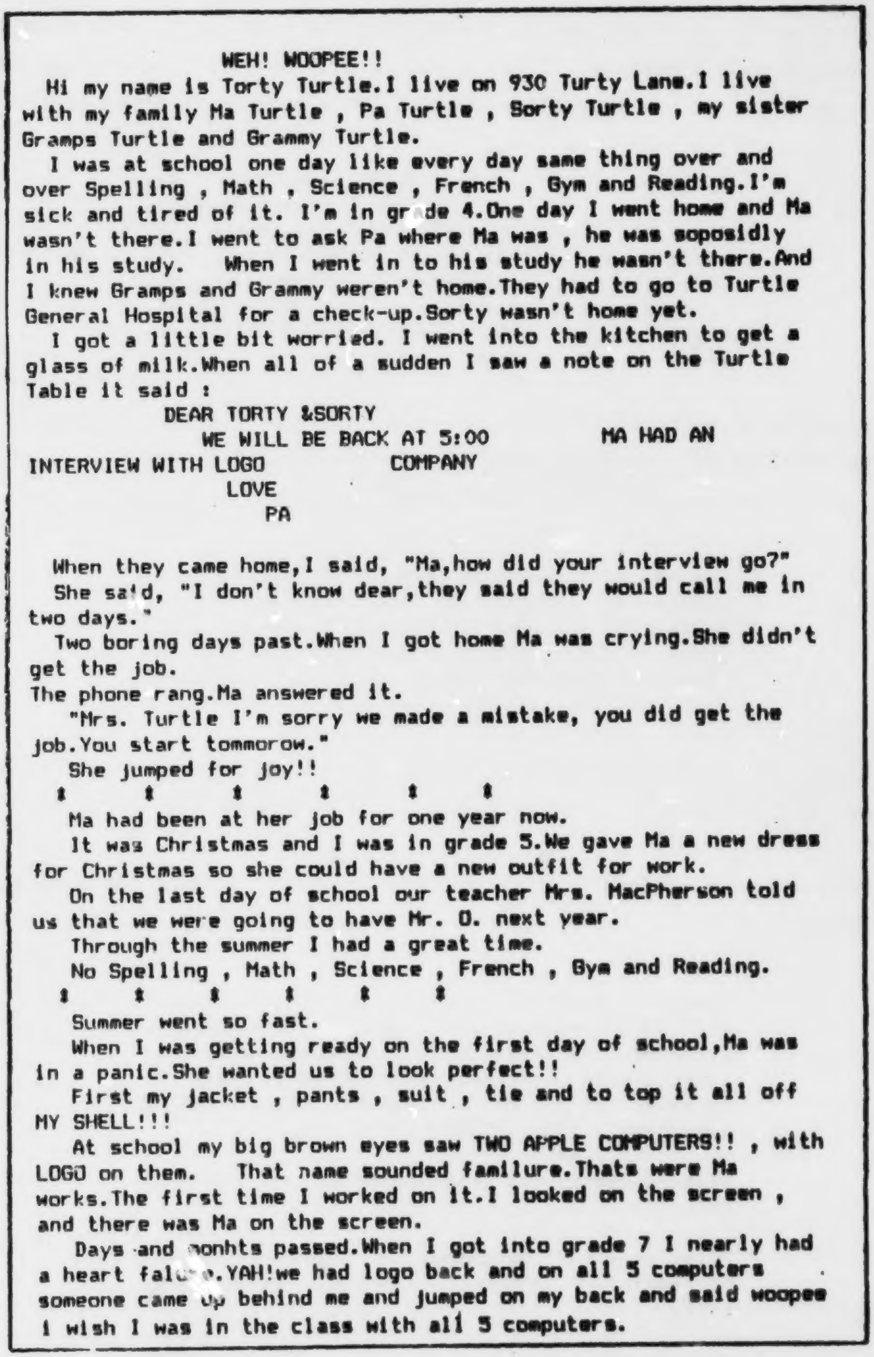
> Kids will write about things which are important to them if they feel their ideas are unconditionally accepted. When a teacher is sensitive about kids' feelings and respects their creative integrity kids will write. They will write about what they are doing on the computer and when they discover that what they have to offer is worthwhile. This willingness (eagerness) extends to other curriculum areas. I am ecstatic about what has been happening in my classroom this year with regard to creative writing. One young man whom I considered to be functionally illiterate in September, writes from choice now. Sometimes he chooses writing during free activity period. An incredible development. May 15/83)

However, the "unconditional acceptance" did not preclude attention to style and details. Both teachers and students felt liberated to attend more willingly to details since the word processor made it easy to revise after the initial ideas were expressed. Proofreading became an important part of the writing program and some writings went through several iterations. Several teachers reported that:

> [Grade 1] The students have created better sentences and stories on the computer. They are not having to concentrate on the writing. (April 13/83)
>
> [Grade 5] They are writing longer stories than they ever have with pencil and paper. (Feb. 11/83)
>
> [Learning Disability Class] Some students are very pleased to be rid of mechanics of writing for a period as this is an area of difficulty for many. (June 15/83)

Figure 22.6

One Example of a Story on "How the Turtle got Into the Computer"; Collected From a Grade 7 Class



WEH! WOOPEE!!

Hi my name is Torty Turtle.I live on 930 Turty Lane.I live with my family Ma Turtle , Pa Turtle , Sorty Turtle , my sister Gramps Turtle and Grammy Turtle.

I was at school one day like every day same thing over and over Spelling , Math , Science , French , Gym and Reading.I'm sick and tired of it. I'm in grade 4.One day I went home and Ma wasn't there.I went to ask Pa where Ma was , he was soposidly in his study. When I went in to his study he wasn't there.And I knew Gramps and Grammy weren't home.They had to go to Turtle General Hospital for a check-up.Sorty wasn't home yet.

I got a little bit worried. I went into the kitchen to get a glass of milk.When all of a sudden I saw a note on the Turtle Table it said :

DEAR TORTY &SORTY
WE WILL BE BACK AT 5:00 MA HAD AN
INTERVIEW WITH LOGO COMPANY
LOVE
PA

When they came home,I said, "Ma,how did your interview go?"

She said, "I don't know dear,they said they would call me in two days."

Two boring days past.When I got home Ma was crying.She didn't get the job.

The phone rang.Ma answered it.

"Mrs. Turtle I'm sorry we made a mistake, you did get the job.You start tommorow."

She jumped for joy!!

$ $ $ $ $ $

Ma had been at her job for one year now.

It was Christmas and I was in grade 5.We gave Ma a new dress for Christmas so she could have a new outfit for work.

On the last day of school our teacher Mrs. MacPherson told us that we were going to have Mr. O. next year.

Through the summer I had a great time.

No Spelling , Math , Science , French , Gym and Reading.

$ $ $ $ $ $

Summer went so fast.

When I was getting ready on the first day of school,Ma was in a panic.She wanted us to look perfect!!

First my jacket , pants , suit , tie and to top it all off MY SHELL!!!

At school my big brown eyes saw TWO APPLE COMPUTERS!! , with LOGO on them. That name sounded familure.Thats were Ma works.The first time I worked on it.I looked on the screen , and there was Ma on the screen.

Days and monhts passed.When I got into grade 7 I nearly had a heart falure.YAH!we had logo back and on all 5 computers someone came up behind me and jumped on my back and said woopee i wish I was in the class with all 5 computers.

The emphasis on proof-reading, combined with the fact that Logo did not accept ambiguities and deviations in the spelling of primitives or stored procedures, reinforced the importance or need for correct spelling. The immediate feedback that students received from the computer was extremely important since it allowed them to reflect and revise on the spot. One student from the learning disability class, while working on a procedure called DIAMOND, was repeatedly switching in and out of the editor. He thus had to type DIAMOND quite often, and invariably he made a mistake. After about an hour he finally exclaimed "Before the day is out I'll never forget how to spell diamonds." His teacher reported that:

> Spelling, especially with some is very difficult. One student who has an incredibly difficult time in this area can spell just about every word he could think of to do with the computer therefore increasing his personal spelling inventory. Also these words can be applied to the learning of new words. (June 20/83)

Many students also seemed to take greater pride in producing a "professional" product. The improved facility with reading, proof-reading, and editing, greatly aided in achieving this goal. For example, a Grade 2 teacher reported that:

> The children are very keen about naming their procedures. They make sure they spell them correctly. Some bring dictionaries and spellers with them (to the computer room) so they can get the names of their procedures correct. (May 12/83)

Grade 3 students and older students were also motivated to be more concerned about correct spelling and structure because, on the computer, it was "more fun" to do so.

Some teachers also managed to draw on their students' programming experience to illustrate components of structure and grammar in writing. They reported that:

> [Junior] Good discussion arose out of Allison and Sally's problems getting the spider procedure to work. They decided Logo was precise and concise: a word we've used in language arts in connection with writing summaries. (Jan .12/83)
>
> [Intermediate] I explained to my students that:
>
> Primitives - procedure - program - top procedure = words, sentence, paragraphs, story.
>
> Writing a composition is like a program with blocks and glue. The blocks are the ideas in one paragraph and the glue is the statements used to join ideas. ... Pupils who previously had difficulty in planning stories are using lessons used and learned in making programs. (Dec. 2/82)

> [Intermediate] The need for precision in syntax is like a very rigid grammar system. (Dec. 3/82)

Teachers were generally impressed with the improvement in overall writing skills:

> [Grade 3] I am so enthusiastic about this development in writing. The stories are so much better written. Content is still weak but the grammar, sentence structure, and spelling is so much better. They were finding out mistakes themselves - proofreading! I have spent six months saying "Did you proofread?" Now they do it automatically. It's fantastic. (March 11/83)
>
> [Intermediate] Evidence has been seen in English where more editing and care to structure has been observed. (April/83)

The degree to which Grade 3 students had developed a "natural" concern for structure and spelling in their compositions is illustrated by the following two observations:

> Robert and Ian are writing about "The Night Before Christmas", a story to go with their Christmas tree picture. They had an animated discussion about the names of Santa's reindeer, and how to spell their names. Some help was sought from their teacher. (Nov. 11/83)
>
> Iris and Sarah are writing a story "Dreams in Space". Easy, natural taking of turns while typing and deciding on the next sentence. For example, "But you can't live on any other planets". Each sentence provided an opportunity for imaging what should be next (two minds in one story!). "We need a really different name for a Martian". They pick "Logray". There was no rough draft or notes before coming to class - they were composing as they went. They would discuss spelling and grammar, e.g., should it be "said" or "saying"; should it be "we ... No, it should be I". (March 9/84)

There were occasions when the picture that students had created in turtle geometry spontaneously engaged them in a creative writing sequel. For example, one of the researchers recorded the following during one of her visits:

> Today Krista and Laurie (two grade three students) are going to write a poem to go with the picture they made yesterday. They wrote a lovely poem and as they wrote they were a picture of happy involvement. There was a lot of discussion and some giggling as they weighed each other's suggestions for the next line. They frequently re-read from the screen what they had written so far and then made corrections or additions. The teacher pointed out one spelling error for them when they called her to read it, and they were happy to

> fix it before they printed it out. An exceptional poem from girls described as low-average and low achievers. (March/84)

Activities that involved interactive quizzes and stories were "naturals" for most students. The level of excitement and enthusiasm rose noticeably in the class when students began to use computers for such purposes. Any activity that called for making a list, combining words, or making choices was ideally suited for Logo with its easy list handling properties. Words could be taken apart and combined. Students enjoyed building humour into many of their simple interactive games. The following observation recorded by an intermediate-level teacher was a common one:

> The development of good quizes, e.g., "Who is the best looking person in the class?" truly caused kids to think about their thinking in order for the computer to ask the multiple questions and give the many humorous responses that the students desired. (June 3/83)

An added factor when writing interactive stories was the value in constructing logical flowcharts which brought focus to the need for proper sequencing of events within a story.

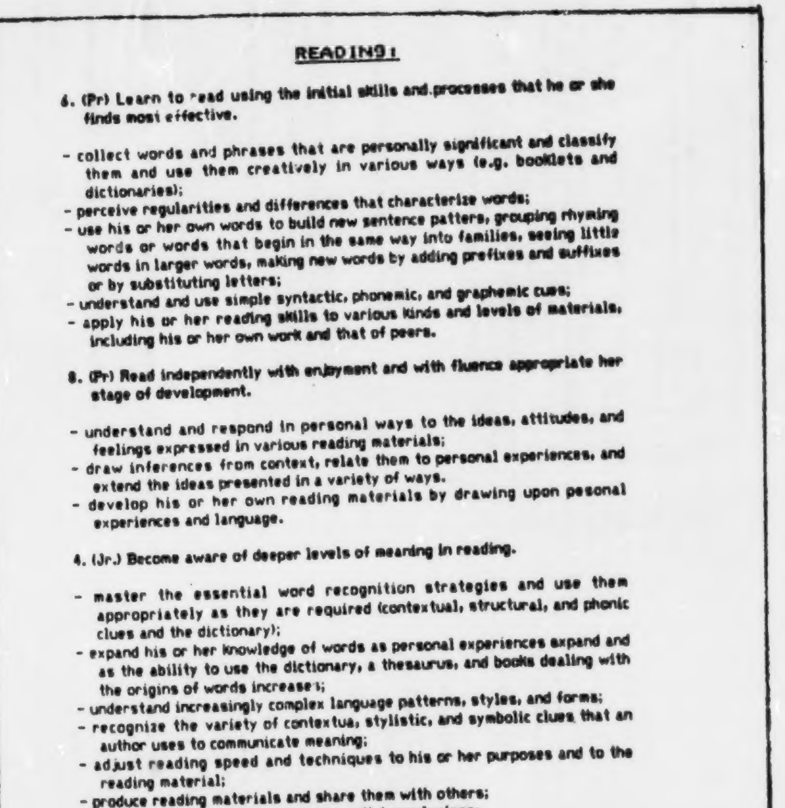
Teachers found that an extensive writing program that took advantage of the computer technology required ready access to a computer and printer for long enough periods of time to permit students to develop their work. Constant access to two to four computers with printers just for writing was considered to be desirable. One Grade 3 teacher indicated that she would teach her students handwriting but would allow her students to do most of their language arts on the computer for the following reasons:

> 1) Only have to do it once - no rewriting a good copy.
> 2) They recognize their mistakes more easily.
> 3) Editing is easy.
> 4) Hard copy is good to look at.
> 5) Writing more - grammatically better, experimenting with new words; proof reading! (May/84)

Other teachers concurred.

Figure 22.7

An Extract From "The Formative Years" Showing the Specific Topics In 'Reading' That Were Explored by Students While Working With Computers



READING:

6. (Pr) Learn to read using the initial skills and processes that he or she finds most effective.

- collect words and phrases that are personally significant and classify them and use them creatively in various ways (e.g. booklets and dictionaries);
- perceive regularities and differences that characterize words;
- use his or her own words to build new sentence patters, grouping rhyming words or words that begin in the same way into families, seeing little words in larger words, making new words by adding prefixes and suffixes or by substituting letters;
- understand and use simple syntactic, phonemic, and graphemic cues;
- apply his or her reading skills to various kinds and levels of materials, including his or her own work and that of peers.

8. (Pr) Read independently with enjoyment and with fluence appropriate her stage of development.

- understand and respond in personal ways to the ideas, attitudes, and feelings expressed in various reading materials;
- draw inferences from context, relate them to personal experiences, and extend the ideas presented in a variety of ways.
- develop his or her own reading materials by drawing upon pesonal experiences and language.

4. (Jr.) Become aware of deeper levels of meaning in reading.

- master the essential word recognition strategies and use them appropriately as they are required (contextual, structural, and phonic clues and the dictionary);
- expand his or her knowledge of words as personal experiences expand and as the ability to use the dictionary, a thesaurus, and books dealing with the origins of words increases;
- understand increasingly complex language patterns, styles, and forms;
- recognize the variety of contextua, stylistic, and symbolic clues that an author uses to communicate meaning;
- adjust reading speed and techniques to his or her purposes and to the reading material;
- produce reading materials and share them with others;
- compare ideas or statements and predict conclusions;

5. (Jr) Use reading as a source of information.

- select realistic goals and formulate manageable questions for individual investigation;
- obtain information from grahic cources such as pictures, cartoons, diagrams, charts, maps, and tables;- act on information received from recipes, directions, manuals, or patterns and evaluate the product;
- organize pertinent information by papraphrasing, summarizing, and recording;
- express personal interpretations through notes, painings, dramatizations, models, maps, or diagrams;

  - test personal interpretations through intereaction with others.

6. (Jr) Develop a deeper appreciation of excellence in reading materials

- read from a diversified selection of materials such as poems, biographies, novels, plays, myths, legends, newspapers, magazines, and cartoons;
- develop an interest in reading for recreational purposes;- react personally in a variety of ways to ideas presented;
- test the validity of personal reactions an dinsights in discussion with;
- develop personal reading tastes and interests.

7. (Jr) Appreciate the significance and function of reading in his or her own life.

- use reading as a source of information and enjoyment.
- respond to print stimuli within the environment, (signs, labels, directions, letters, initials)
- organize and record information.

Figure 22.8

An Extract From the "Formative Years" Showing the Specific Topics in 'Writing', in 'Perception and Expression', 'Drama', 'Music,' and 'Visual Arts' That Were Explored by Students While Working With Computers

WRITING:

6. (Pr) Express experiences, thoughts, and feelings in writing with clarity and sensitivity.

- master a vocabulary of words, phrases, and expressions through which personal feelings, sensations, and observations can be adequately expresedd- experiment with words, word patterns, and idioms;
- develop a sense of sequence and logic that enables individual progress fromisolated phrases or sentences to the coherence of a paragraph;
- demonstrate an appreciation of style by incorporating in his or her own writing effective words or phrases selected from thos encountered in reading and listening;
- demonstrate a Knowledge of the patterns of spelling and rules of punctuation required for clarity.
- demonstrate a Knowledge of common grammatical forms.
- write legibly in a manner appropriate to his or her stage of development.
- use writing for creative expression (e.g. stories and verses);
- use writing for practical puposes (e.g. sequential instructions for specific opeations or short letters requesting permission or information);
- assess his or her own writing in appropriate ways;
- appreciate that writing can be used to inform, to explain, to describe, to narrate, and to give voice to imagination and fantasy.

7. (Jr) Express in writing personal experiences, thoughts, and feelings with greater clarity and sensitivity

- selelct, record, and use intersting words, phrases, and expressions gathered in the course of personal experiences or obtained from a dictionary or other reference source;
- present ideas and information logically in paragraphs and in outlines and reports;
- experiment with more compact phrasing and interlocking constructions;
- demonstrate a growing knowledge of standard grammatical forms;
- demonstrate a growing knowledge of the patterns of spelling and rules of punctuation required for clarity;
- understand how words are put together, identify syllables, recognize and use prefixes, suffixes, root words, synonyms, antonyms, and homonyms.
- demonstrae a growing ability to present thoughts, feelings and experiences ina personal style.

8. (Jr.) Understand that writing can be used for many purposes and that the purpose determines the form of writing and the kind of language used.

- adapt language to the intended purpose so that it effectively expresses personal experiences and feelings;
- acquire and demonstrate the ability to use different forms of writing (e.g. diaries, letters, instructions, outlines,tams or scripts, records of trips or experiments);
- communicate through imaginative and personal forms of writing (eg. stories, plays, poems, fables);
- recognize and appreciate models of good writing;
- recognize that facilty in writing is gained through practice;
- appraise and improve writing in the light of the purpose or audience.

PERCEPTION AND EXPRESSION:

1. (Pr.&Jr.) Increase sensitivity of perception through the use of all the senses and develop the capacity to express this sensitivity through a variety of creative media.

- appreciate that his or her own ideas and feelings have value and are worthy of expression;
- develop the ability to express his or her ideas and feelings through active participation in drama, music, physical education, and visual arts;
- use the opportunities provided by the arts to practise problem-solving both independently and co-operatively.
- enjoy the power of creation through the use of colour, pattern, movement, sound, language, and materials;
- develop the freedom of thought necessary for creativity.

DRAMA

2. (Pr. & Jr.) Develop self-awareness and self-confidence through drama and related creative activities.

- discover and clarify assumptions, points of view, and emotional reactions and gain an awareness of is or her role as well as the role others play.
- co-operate with others and develop empathy with them by working with them and exchanging ideas freely;
- develop the abilty to concentrate and gain confidence from growing powers of self-expression;

MUSIC:

3. (Pr. & Jr.) Develop sensitivity to sound and thus acquire a base for growth in music

- enjoy and experience music through singing, playing, listening, creating, moving, and dramatizing;
- produce and experiment with sounds through a variety of means in order to become increasingly sensitive to rhythm, pitch, dynamics, timbre, form, melody, and harmony.
- become familiar with and develop the ability to use the language and grammar of music as a means of cummuication.

VISUAL ARTS

4. (Pr. & Jr.) Develop visual awareness, sensitivity, and appreciation

- experience and respond to forms, events, and materials in the environment;
- clarify and express personal experiences and feelings in visual form through a variety of materials and activities such as modelling, construction, painting, and drawing.

23. THE ARTS

The teachers in this study were committed to encouraging students to develop and use their own ideas. Since turtle geometry is a graphics medium, artistic concepts and artistic creation were an intrinsic part of the activities that involved its use. One intermediate-level teacher expressed this the following way:

> I am not an artist, but I agree with the children that Logo makes pretty pictures. The children get enjoyment from this aspect of Logo. Sometimes a problem-solving task becomes an artistic one, e.g., "make a circle". The children were quickly using circles and parts of circles (arcs) to create bugs and other pictures. (Dec. 3/82)

The Koala Pad (a graphics tablet) offered another computer medium for artistic expression. Any medium limits or enhances the degrees of freedom available to the artist in giving shape to an idea. Turtle geometry was limiting in the sense that an idea could only be executed by means of a series of incremental steps, or as procedures that demanded careful logical analysis. On the other hand, if students did not have a particular shape or form in mind, turtle geometry allowed them to create pleasing results merely by entering commands or procedures without much prior analytic thought. The results obtained by this process often became a "trigger" for their imagination and led to artistic expression in the same medium or in another, such as writing a poem or writing or telling a story. The use of the Koala Pad does not demand programming skills and is analogous to the process of drawing by hand. However, if students restricted their designs to using preset shapes, their artistic creations were limited by the choices available on the "menu". Both turtle geometry and the Koala Pad were limiting in the number of colours available to the artist. The freedom students gained with either turtle geometry or the Koala Pad was the opportunity to experiment with form, shape, and colour with relative ease. Once certain "building blocks" (which were either preset on a menu, offered by the teacher, or designed by the students) were available to the students, they could be moved to many different locations, their relationship to each other could be assessed and changed if necessary, and only the final "satisfactory" product needed to be saved. Ideas could also be expressed, evaluated, and revised in part or as a whole with relative ease and without having to recreate everything from scratch. Teachers felt that this freed students' inhibitions and that it made them more willing to experiment and to express their ideas:

> [Junior] There appears to be less inhibition on the computer, i.e., to make something different. In art class the students seem to lose this freeness when given a piece of paper and asked to construct something. (Feb./83)

> [Junior] The drudgery is gone. The painstaking work is gone but the thinking is there. In fact, energy can be focused here. If it's not what you want or expect, change is easy and fast. (May 15/83)

> [Junior] They seem to be able (and willing) to take the time to draw more intricate and aesthetically balanced designs on the computer. Drawing free hand would be too difficult and time-consuming. Computer graphics final product to be commensurate with the creative idea. (Dec. 13/82)

> [Learning Disability Class] We do much in the area of art in our classroom - many children shy away from putting pencil to paper to draw something because they feel truly impotent in this area - hence, most of our activities tend toward other art concepts. However. with the computer they were extremely pleased with all results! Different combinations of line, shape and colour were attempted. Some completed pictures were totally unexpected but were always relished by artist. (June 20/83)

> [Emotional Adjustment Class] The effect happens much faster on the screen than on paper and as the final product can be seen almost immediately it makes the goal seem less distant! ... Making interesting pictures that use patterns over and over again are a "treat" with the Draw Mode. (May/83)

Students also explored with colour through the use of various pen-colours and background colours. A particularly engaging activity for many students at all grade levels was that of changing background colours and observing the visual effect this had on their design. The combination of various pen-colours and background colours made students aware of the effects of superimposing certain colours and enabled them to assess the interrelationship of different colours with relative ease. Both Logo and the graphics tablet allowed students to create "neater" and more intricate designs than would have been possible without the computer. One Grade 3 student once commented: "I know what I want to draw and the turtle does it so much better than I can". Many teachers observed similar reactions in their class:

> [Grade 3] These children are producing designs using Logo that they themselves could never reproduce. ... simply turning a polygon creates a beautiful design. Simple figures can make complex designs. Young students who cannot draw a circle or even a straight line by themselves very much enjoy exploring designs and colour with the computer. (April/83)

> [Intermediate] Computers are easy to erase and quick to re-do. This is most useful. ... The children do not have the skill with

> protractors and compasses to do the designs they do on the computer. (Nov. 24/82)

Elements of symmetry, harmony, contrast, balance of composition and space, the use of lines and shapes, the blending and balancing of colours, optical illusions, and perspective all came into play at various stages and grade levels as students created their pictures and designs.

In addition to the actual artistic work on the computer, designs or text produced on the computer and printed out on paper became integral components of conventional artwork. Grade 3 students made their own geometric designs or created their own "scenes" on the computer, which they then printed out and coloured with crayons or embellished with additional pencil drawings (Figure 23.1-A). Grade 1 students used graphics or text printouts as components or backdrops for their traditional art work (Figure 23.1-B). Also, the visual images created by "wrapping" designs eventually became internatilized and found expression in Grade 1 students' brush paintings as they designed the background for their paper collages (Figure 23.1-C). Wrapping designs which started out by merely typing large numbers into a series of commands, eventually became much more "directed" in order to achieve a specific effect that the artist wanted to create (Figure 23.2). Other forms of artistic expression were generated by junior-level students as a spin-off from their computer activities. They made stuffed paper puppets of "Appledumplings" (their name for the triangular 'turtle') and hung them from the ceiling of their classroom. They also presented a series of puppet plays to a primary class. These plays gave life to characters such as "Appledumpling" and the "The Circler" as well as to other non-computer characters. One of the researchers who received a private showing during one of her school visits recorded the following in her notebook:

> The plays were filled not only with computer characters but with computer terminologies and ideas. ... In one story, coloured lights flash on the screen (a rainbow of coloured paper moved across the stage), and Mrs. Cook is pulled into the computer because, "Oh, oh, someone pressed RETURN while she was standing too close to the computer". Imaginative and well presented puppet plays. (April/83)

Figure 23.1

A: Two Examples of Geometric Designs Created and Coloured by Students Collected From a Grade 3 Class

B: Examples of Text and Graphic Output Produced by Grade 1 Students That Were Integrated Into Conventional Art Forms

C: An Example of a Collage Created by a Grade 1 Student That Illustrates the Integration of the Image of a 'Wrapping' Pattern Commonly Produced on the Computer Into Conventional Art Form

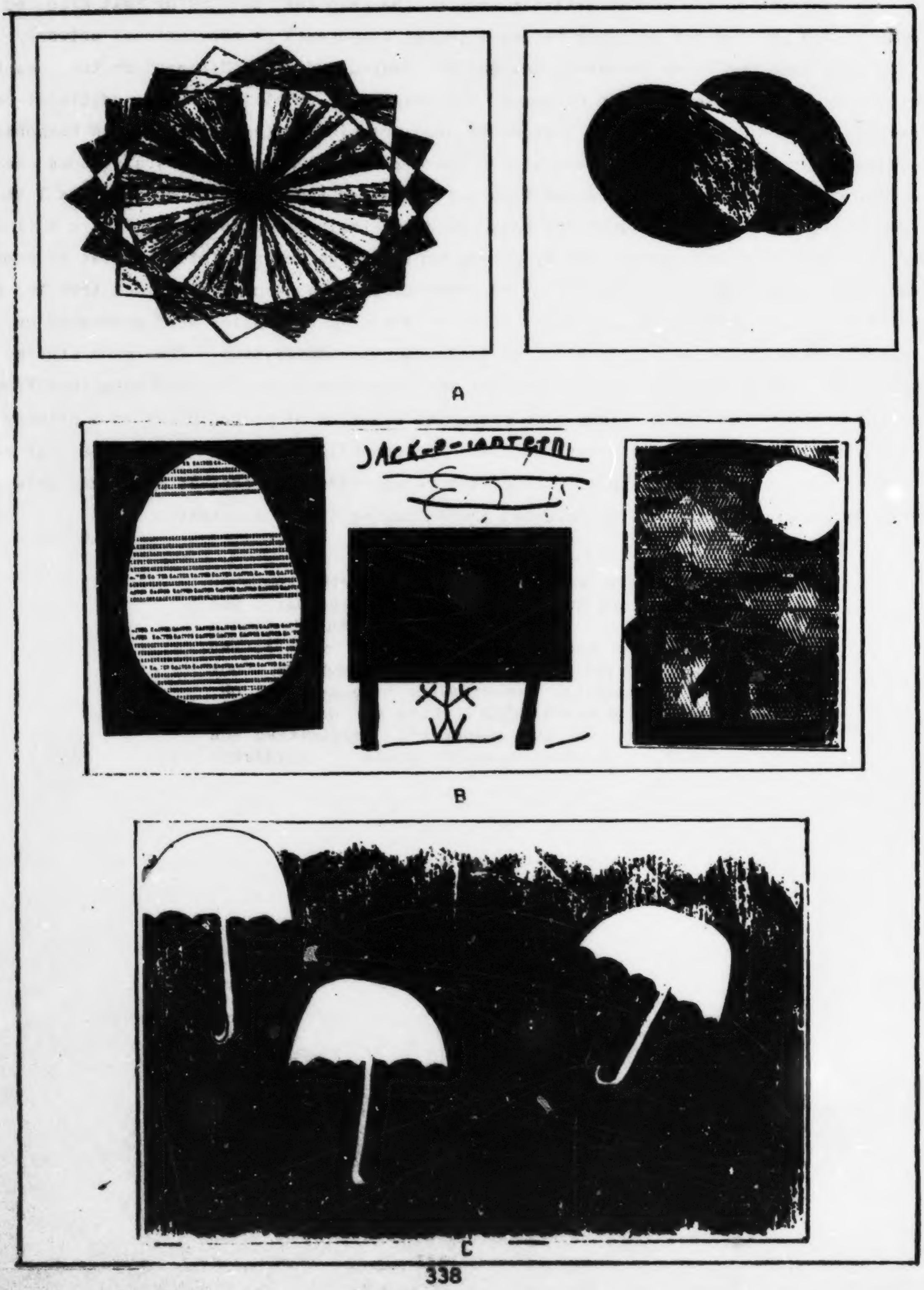
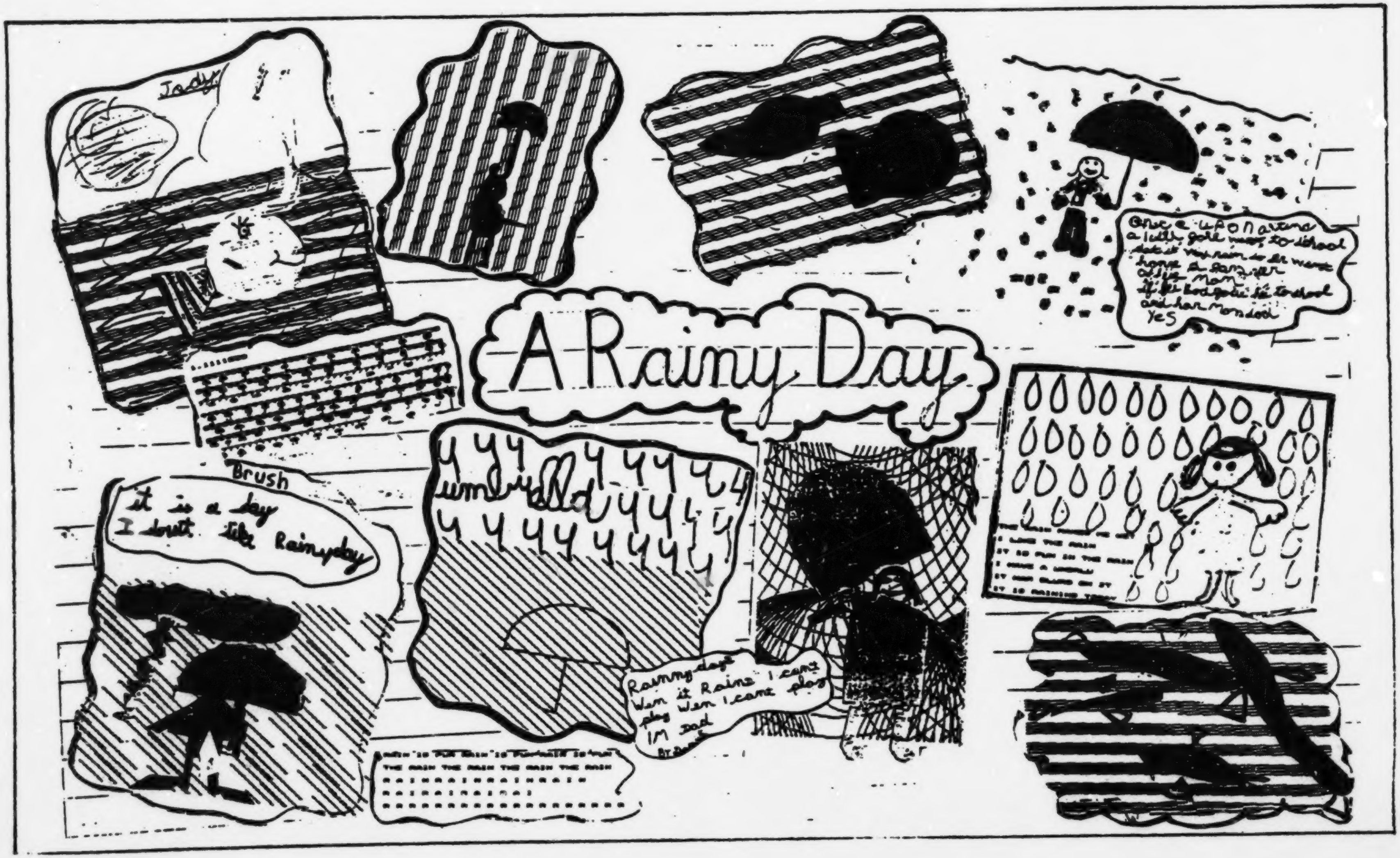


Figure 23.2

'A Rainy Day': A Grade 1 Class Collage That Uses 'Wrapping' Designs Produced on The Computer as Background to Depict 'Rain' and 'Water'


Jody
A Rainy Day
Brush
it is a day
I dont like Rainyday
umbrella
Rainny days
Wen it Rains I cant
play Wen I cant play
I'M sad
YES

24. VALUES AND THE INDIVIDUAL AND SOCIETY

The context within which computers were used gave many opportunities for students to learn more about their own values as well as those of others. Working in pairs on computers brought into play the tension between different individual needs. The scheduling of computers in the classroom brought forth questions of equitable access. The opportunities for students to create original designs and programs raised issues about the rights of the creator with respect to receiving recognition for his or her work and ideas, and the creator's obligation to share his or her ideas with a group or society. Strategies of resolving these dilemmas were discussed by students as young as Grade 3. Almost all students experienced being "teachers" at some time during the study. They were able to experience education from a different perspective, which gave them greater insight into the world of their adult teachers with whom they interact daily. In one of the junior-level classes, students were given a chance to teach mentally handicapped students about Logo. In preparation for this event, they learned about autism and some of the causes that lead to mental handicaps. These lessons were not an abstract activity but a living experience, as the letters presented in Figure 24.1 show.

Many issues related to social and human values arose on one occasion in an intermediate-level class, when the teacher asked his students to form themselves into small groups and, as a group, decide on a project that everyone in the group could work on. The teacher nominated group leaders but other students were free to go with any of the group leaders. Great difficulties arose because students ran into conflict with other group members, group leaders found themselves leading others who were more knowledgeable about computers than they were, some students felt intimidated by others hence they could not contribute their fair share to the group effort. This situation created tears for some and a lot of confusion for others. The teacher chose to turn this confusion into a real learning experience for everyone. He reported the following:

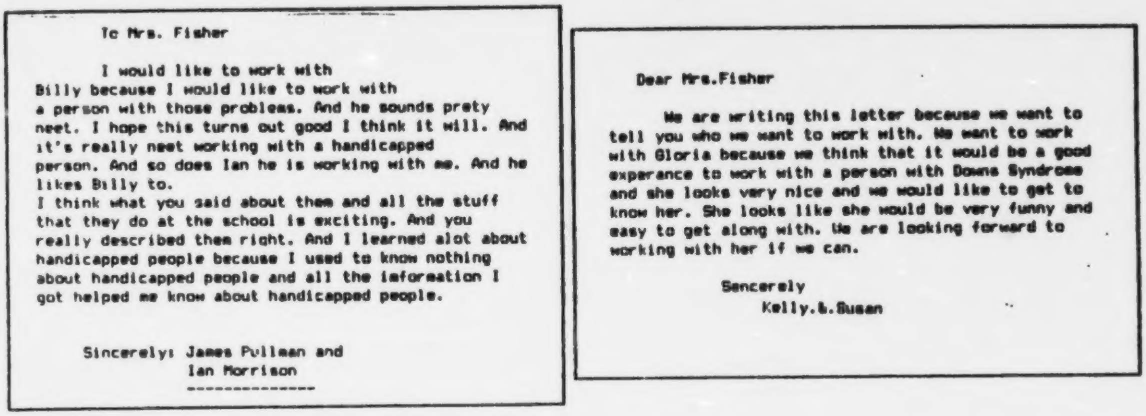
> Maybe our computer work was the pits but the human growth will be of benefit. These are some of the questions that arose out of the subsequent discussion:
>
> - What is authority, responsibility?
> - Who chooses authority?
> - Why do we have authority, responsibility? -
> How is it (assignment, authority, work)
>   our friend?
> - How should I respond to authority?

- **How can I change it?**
- **How can we, as a group, handle a problem without hurting others?**
- **How can I be in charge and still be a friend?**
- **How do you organize something you don't know anything about.**

Social interaction, human growth and development, and peer relationships are a constant part of any classroom life. Objectives such as those mentioned in The Formative Years (Figure 24.2) were regularly addressed while working on computer-related activities. The experiences and the consequent learning were always based on real events that had immediate relevancy to the students. In order to teach a "lesson", situations did not have to be contrived or drawn from a preset unit or "kit". It did, however, require flexibility and confidence on the part of the teacher to teach "the lesson" when an immediate and real need arose.

Figure 24.1

Two Examples of Letters Written by Grade 6 Students to the Teacher of a Mentally Handicapped Class Before the Two Classes Became Involved in an Exchange



To Mrs. Fisher

I would like to work with Billy because I would like to work with a person with those problems. And he sounds prety neet. I hope this turns out good I think it will. And it's really neet working with a handicapped person. And so does Ian he is working with me. And he likes Billy to.

I think what you said about them and all the stuff that they do at the school is exciting. And you really described them right. And I learned alot about handicapped people because I used to know nothing about handicapped people and all the information I got helped me know about handicapped people.

Sincerely: James Pullman and
Ian Morrison

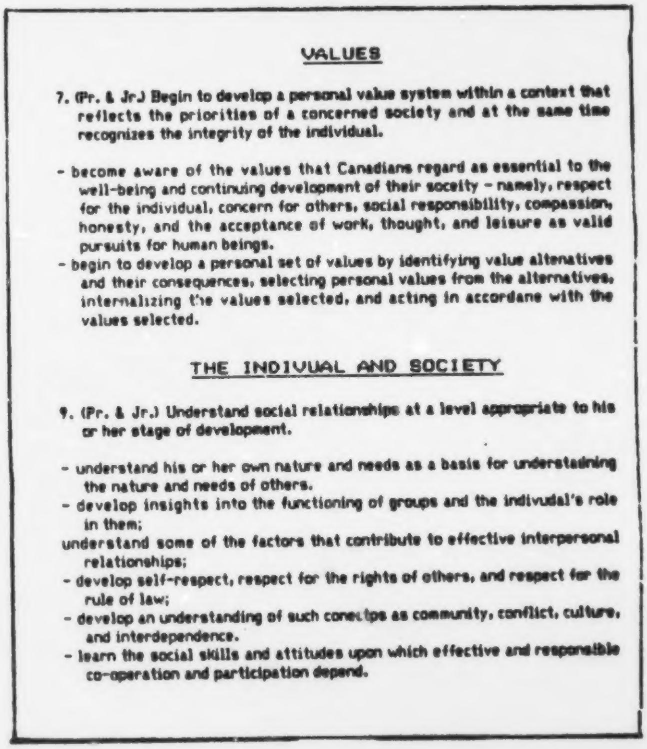
Dear Mrs.Fisher

We are writing this letter because we want to tell you who we want to work with. We want to work with Gloria because we think that it would be a good experance to work with a person with Downs Syndrome and she looks very nice and we would like to get to know her. She looks like she would be very funny and easy to get along with. We are looking forward to working with her if we can.

Sencerely
Kelly.&.Susan

Figure 24.2

An Extract From The "Formative Years" Showing the Specific Topics in 'Values' and 'The Individual and Society' That Were Explored by Students While Working With Computers



VALUES

7. (Pr. & Jr.) Begin to develop a personal value system within a context that reflects the priorities of a concerned society and at the same time recognizes the integrity of the individual.

- become aware of the values that Canadians regard as essential to the well-being and continuing development of their soceity – namely, respect for the individual, concern for others, social responsibility, compassion, honesty, and the acceptance of work, thought, and leisure as valid pursuits for human beings.
- begin to develop a personal set of values by identifying value altenatives and their consequences, selecting personal values from the alternatives, internalizing the values selected, and acting in accordane with the values selected.

THE INDIVUAL AND SOCIETY

9. (Pr. & Jr.) Understand social relationships at a level appropriate to his or her stage of development.

- understand his or her own nature and needs as a basis for understaining the nature and needs of others.
- develop insights into the functioning of groups and the indivudal's role in them;

understand some of the factors that contribute to effective interpersonal relationships;

- develop self-respect, respect for the rights of others, and respect for the rule of law;
- develop an understanding of such conectps as community, conflict, culture, and interdependence.
- learn the social skills and attitudes upon which effective and responsible co-operation and participation depend.

Part Six: Conclusions and Implications

25. ROLE OF THE TEACHER

26. STUDENTS-EVALUATION OF THEIR COMPUTER EXPERIENCES

27. CONCLUSIONS

PREAMBLE

Although the impact of the creative uses of computers on the role of the teacher has been documented throughout this report in various forms, Chapter 25 summarizes a few key issues and incorporates how students see the role of the teacher, and the impact they foresee that computers will have on the way teachers will teach and students will learn in the future. Chapter 26 presents the way in which students perceived computers within the context of all their various classroom activities, and summarizes what, among the various computer activities, students enjoyed the most and least. It also shows that if students were given free choice about their computer activities, video games would not take over, although interest in them was quite high. Chapter 27 offers a brief summary of key findings and their possible implications for education and further research.

25. THE ROLE OF THE TEACHER

It is not uncommon to find references in the literature and in the popular media which suggest that computers will replace teachers (usually in connection with programmed instruction material). This study, however, provides strong evidence that the creative use of computers makes very considerable demands on teachers and that the teacher is an indispensable part of a student's learning process. One teacher commented:

> Each and every student has been affected in some way - some more notably than others. Right at this point I feel I have struck a gold mine but isn't it wonderful to know that they still need ME! (March 11/83)

The teacher in the "creative learning situation" of our project needed to be aware of both the process and the product of the learning event and to be a facilitator and co-ordinator in furthering the student's learning. For some, this required a different approach in teaching strategies since the premise for teaching was no longer an externally prescribed curriculum or text but the particular educational needs of a student - an approach to teaching that may be unfamiliar to some teachers. One teacher had the following to say:

> The creative use of the computer is the same principle as the creative use of any idea or tool. I'm not sure the computer will be able to change a teaching philosophy which may be firmly entrenched. A teacher who feels a necessity to be "in charge" will structure her class so in all curriculum areas. A "product" oriented teacher will not understand "process" oriented curriculum. Perhaps compulsory re-education of teachers is a possibility which needs looking into. (Dec. 13/82)

Teachers also found themselves re-examining the notion of what it means to be creative. Some teachers felt that being creative with Logo meant allowing students to draw on their inner knowledge and resources with minimal input from the teacher. Such an approach had limited success with students of all ages and abilities. Some direction for acquiring the Logo language and for independent exploration had to be given to all students, especially at the outset. The learning styles of the students also had to be accommodated. Some students needed the security of structured explorations before they were willing to venture forth with their own ideas. Others were more willing to take risks and explore through trial and error or by bringing ideas from other computer domains, such as BASIC or video games, to their Logo explorations. Teachers needed to be sensitive to these different learning styles and to offer opportunities for creative exploration accordingly. Although most teachers were willing to make the Logo experience a joint learning experience, most of them also found that they were better able to assist and stimulate students in their explorations if they had at least a working knowledge of the language, or access to someone else with that knowledge who could act as a consultant to them and/or their students:

> [Primary-Grade 1] I was unable to devote time to working with Logo and, therefore, felt that I was unable to encourage the students to try and/or discover for themselves. (Dec. 1/83)
>
> [Junior] Since the response I had to my lessons on the uses of variables, I have decided that these types of demonstration lessons in Logo are useful too. The kids have developed to the point where they need only a little instruction in Logo in order to use it to go on. (Feb. 28/83)
>
> [Intermediate] Teachers need more time to work on Logo themselves, for in order to challenge the students, the teacher must have had the experience of doing it themselves. (Feb. 8/83)
>
> [Emotional Adjustment Class] Learning together, student and teacher, has its advantages, but there are certain times when questions are asked and answers are not possible at that point. Teacher training before would be helpful. (May 15/83)
>
> [Learning Disability Class] Only problems encountered thus far are due to my lack of knowledge. I told class that many things we are learning together. They seemed to accept and appreciate this. (March 11/83)

Despite this desire and need to know more, all the teachers in this study were willing to explore a new role: that of co-learner. They felt they could engage in such a role because there were no curricular objectives to be met. The activities of Logo were free of academic expectations. In the words of some of the teachers:

> [Primary] Because there is no definite goal or concept you are trying to achieve, the interaction between yourself and the student is less tense. You assist them in an inquisitive and excited way because in many cases, you as the teacher, are not sure how things will turn out either. (May 12/83)
>
> [Junior] The emphasis has not been on teaching and testing knowledge of Logo, but rather teaching what they (students) need to know to create designs and pictures that are satisfying to them. Their Logo work is not an end in itself but another interesting activity to think about, talk about and write about. (Nov. 12/82)
>
> [Intermediate] Right now the computer use facilitates rapport because it is regarded as

> a bonus and a special interest rather than as a mandatory part of the curriculum. (Nov. 12/82)
>
> [Intermediate] Logo has been an interaction of the pupil and computer on a creative level; there has resulted a very pleasant atmosphere where, as the teacher, I am not marking pupils against an academic standard. (April 15/83)

Those teachers who were successful at turning the Logo experience into a joint learning experience found a new adventure in teaching. Teachers recorded the following reactions:

> [Primary - Grade 2] The teacher becomes something of a technician as well as a co-learner, a friend, and a motivator. (May 12/83)
>
> [Junior] Because there are no absolutes in creative Logo, teachers are freed to become involved in the class' learning as a participator as well as the (ultimate) director. As students' confidence grows and their self-concept develops, they become eager to participate in the structuring of their learning. The teacher may develop as more of a group leader than a traditional autocratic authority and disciplinarian. (May 15/83)
>
> [Intermediate] The teacher will no longer be looked upon as the great feeder of information, but more as a co-ordinator, since the student will explore on his own and will teach himself new concepts. ... If the teacher so desires, truly, the teaching role can become one of facilitator rather than lecturer most of the time. ... it can become a celebration of discoveries. ...
>
> [Intermediate] This (Logo) allows a different kind of interaction. I can work with students as an advisor. Their result is their judge. (April 15/83)

Despite this willingness to engage in a co-learning situation, almost all teachers, even the ones with the most computer experience, experienced some unease when individual students quickly reached or surpassed their knowledge and capability with respect to the computer language. This happened rather quickly at all grade levels. One intermediate teacher reported that:

> My frustrations with Logo include: my own inexperience with Logo; with a large group so many advance more rapidly, that "teacher, teacher" can become a pain; so many pupils want to do things - progress to more advanced designs - when they don't have the necessary background skills. (Jan. 13/83)
>
> Len is getting to be a pain. He is so far ahead of the others with his ideas that he "fires" up other students to try things for which they aren't ready yet. (May/83)

One intermediate-level teacher who felt unable to direct the learning of some of the more advanced students, put the computer on "hold" for the whole class until he had a chance to assess the situation.

"If the teacher is no longer to be a 'subject expert', then what is the role of the teacher?" This question in one form or another caused many teachers to examine the Logo experience at considerable depth because it brought into question the meaning of being a teacher and a professional. Professionalism implies a knowledge or expertise in a particular field that is not readily shared by people outside a specific profession. If the assumed knowledge is no longer entirely in relation to content, then what are the necessary and desired skills or qualities that define teaching as a profession? This question is not entirely new in education, since teachers of gifted students have had to deal with this long ago. It was found that these teachers needed to have a general joy for learning and to welcome the new and the unexpected. They also needed to possess an understanding of the learning processes and strategies, and an awareness of the available resources (human and non-human) that could further a student's own inquiry and, if at all possible, a sense of humour so that they could laugh at themselves and with their students. Teachers in these situations were both guides and partners. The teachers in this study who had the greatest impact on students' self-confidence and/or knowledge acquisition approached Logo in just such a manner. For example, the Grade 3 teacher reported:

> A teacher needs to be more flexible. Realise that the teacher cannot be the programmer and have all information. Teachers need to be aware of how and where students may be able to get help and assistance. Be able to evaluate and select appropriate software. (April 13/83)

Such a role demanded a greater degree of personal security on the part of the teacher since, as students gained confidence to discuss their own ideas, they were also more inclined to challenge the teacher. For example, two teachers wrote:

> [Junior] These students depend very little on my approval for their work done on the computer. They've never asked, "Is it OK?", etc.. This attitude seems to be spilling over to other areas. I do feel the kids are demystifying the teacher's image. They know I'm learning with them in Logo and they seem to trust that I respect their ideas in other things too. They don't hesitate to tell me (or ask me) if they see a better way or a more fair way to handle things. (Dec. 13/82)
>
> [Emotional Adjustment Class] Investigation and development as "learner" promotes discussion and causes students to defend a point or to look further, knowing both himself and teacher are learning "together". (May 15/83)

The positive spin-off of such independence may actually lighten some of the demands on a teacher's time. One junior-level teacher wrote:

> Because Logo allows as many different ideas as people working in it, everyone can contribute to the learning in a classroom. Teachers and students can interact in a more positive way if the teacher feels secure enough to allow it. Because students can be allowed to own their own problems in Logo, they can easily take the next step to owning their own social problems. The teacher can become a counsellor, a motivator, instead of the sole authority. She can lead the students to learning how to make decisions about themselves, their learning, etc.. (May 15/83)

Not being the "sole authority" also gave teachers the freedom to become living role models to their students on "how to learn". Students were able learn from seeing this process in action rather than from merely being told what to do.

When junior and intermediate-level students were asked, at the end of the second year, "Do you think computers will affect the way teachers will teach in the future?" only 6% of them indicated that the role of the teacher might change. However, when these students were also asked, "Do you think the way you learn with a computer is different from the way you learn without a computer?" all but 9% of the students indicated "yes" (Table 30). Fifty percent of the students listed differences that favoured learning at the computer. Many of these differences would also imply a change in current teaching practices. Although only 8% of the students listed differences in favour of the teacher, one junior-level student took it upon himself to speak on behalf of others:

> Probably they'd be making programs for teaching kids so the computer teaches them but if they even use that idea it probably won't work out because the kids would complain (at least I would). When the computers teach them and say very good or something, they don't know if they really mean it. It wouldn't be able to show affection like a real teacher could because really, when you think about it, it is just a small piece of dumb metal with microchips inside, and it helps you with things.

Some of the different roles that students saw for teachers in the future were expressed in the following way:

> Some computer programs are already teaching kids things. I think teachers will still teach but computers will do most of the teaching, teachers will do the explaining.
>
> In the future I think kids will be able to learn right from the computer and teachers might only have to supervise.
>
> Teachers won't necessarily teach that subject but they will have to make the programs and be there if students need to question something when the computer couldn't answer.

On the whole, students tended to see a greater impact of computers on the way subjects would be taught - primarily by or on the computer (34%), and on the teaching strategies that teachers would use (34%). Some examples of new strategies given were:

> I think that the teachers will teach a lot differently ... We will get our report cards from a word processor and they will type our work on the computer instead of standing up in front of the class and explaining it.
>
> I think in the future many teachers will have a big screen in the front of the classroom and instead of boards and chalk the teacher can stay at his/her desk.
>
> I think the teacher will be able to just push a button and the lesson comes on the monitor.
>
> Our work will be kept on disks and kids will have a computer on their desks.
>
> Teaching will become quicker and more simplified.
>
> More will be taught. More information will be kept on disks and not become lost.
>
> Yes, because when they [the teachers] were students they had computers so they will almost think computers.
>
> I think it would be harder for the teachers because the teacher (if not organized) would get an overload of work to teach and may not be able to handle it.
>
> The teacher will have an easier job because a computer can do lots of stuff for teachers. They can do all sorts of drills in different subjects and it will be easy for teachers too.

Eighteen percent of the students thought that computers might replace teachers, and 8% thought that computers would have no effect on teaching in the future. Some of the reasons for the latter, interestingly enough, dealt with issues of control:

> I don't think it will [make a difference] because when it's time to work, the teacher could just say if you go near the computers you will get a detention.
>
> I don't think so because teachers have an idea of what they are teaching. Some teachers feel that they are not going to let a machine tell them what to do.

And the ultimate control:

> Computers will never really take over. A computer can't keep a class quiet. If the computer tells the class to be quiet the class can just turn it off.

Table 30

Responses to "Do you think the way you learn with a computer is different from the way you learn without a computer? Explain"

Number of respondents	Primary 29	Junior 33	Intermed. 59	Total 121
	Frequencies			
"Yes" Responses:				
Learning Modality:				
Fun way to learn	-	10	4	14
Can do more/different things	5	2	4	11
Have to think harder: solve own problems, challenges	2	4	3	9
Immediate feedback	3	1	3	7
Don't have to think so hard: computer or book gives answer	2	-	3	5
Can experiment, more creative	-	3	1	4
Work alone at own speed	1	-	3	4
Easier to make corrections	1	1	1	3
Learning without knowing it	-	1	1	2
Different thinking style	-	-	1	1
Mechanical:				
Keyboard vs. pencil	7	3	4	14
First need to know how to use computer	-	1	7	8
Straighter writing, better pictures	5	-	-	5
Learn to type	-	1	1	2
Computers are distracting	-	1	1	2
Must spell correctly	-	-	1	1
Teacher related:				
Can't ask computer for help	-	-	5	5
Teachers can teach more	-	1	1	2
Teachers are enthusiastic	-	1	-	1
Computers can't show affection	-	1	-	1
Computers are patient, teachers not	-	-	1	1
"No" Responses:*				
Still learn same lessons	-	-	9	9
Teacher uses computer to demonstrate	-	-	1	1
Don't learn major things on computer	-	-	1	1
No answer	3	2	3	8

Note: * all from class that used computers very little

26. STUDENTS' EVALUATION OF THEIR COMPUTER EXPERIENCES

Without any doubt, students found computers a highly motivating medium for exploration and learning. All but three of the 433 students in the study enjoyed working with computers. Interest in computers as an entity to be studied as well as a possible medium for general learning remained high among students. When at the end of each of the two years students were asked if they would like to learn more about computers, all but a small percentage indicated that they were still interested in learning more, although some were more eager to do so than others (Figure 26.1). However, students were less certain about mandating that "every student should know something about computers" (Figure 26.2). Even though the individual interest in computers remained high, after some initial enthusiasm, students were able to place computers rather quickly into a balanced context. When primary-level students were asked "What kinds of things do you like to do when you are at school?" their responses indicated a balanced interest (Table 31). When junior- and intermediate-level students were asked "Which subjects or activities do you like the most?" computing faced stiff competition from gym and shop or family studies - especially in the spring (Table 32). Computers often found themselves relegated to second or third place. One intermediate-level student confirmed during an interview that there was a right "season" for certain interests:

> I found in the winter I really wanted to get on the computers in the afternoons and during recess times. Everyone would charge for the computers and the first ones to get there would get on and have a pick of the computers. I would try to get on all the time, but right now at lunch time and recess no one tries. Everyone just leaves; they'd rather be outside. (June/84)

There was one exception to this finding at the junior-level (site 7a). The students in that class had not been exposed to computers at the time the pre-questionnaire was given in the fall, and they had only been introduced to word processing and other educational software a few weeks before the post-questionnaire was given in the spring. Another exception was noted in one class at the primary level (site 2a), where students had access to three computers throughout the day and the teacher had succeeded in integrating the computer with many traditional classroom activities. There were individual exceptions within classes. Some students did not take advantage of all their scheduled time on the computers and others were eager to take up those "free" periods. A few "hackers" emerged in these situations but they too seemed to learn that there was more to school or to life than computers. For example, one intermediate-level student reported that:

> In the middle of the year I was a computer addict and my grades really went down so I had to stop. (June/84)

When students were asked, approximately two months before the end of each of the two years, "Of all the things you have done on the computer what did you like the least?" 28% found nothing that they disliked. With respect to turtle geometry only 6% didn't like it, and another 28% didn't like some specific activity or function within turtle geometry or Logo (Table 33). By contrast, 58%, of the students enjoyed turtle geometry or some specific activity or aspect within Logo the best (Table 34). "Other software" ranked next highest at 17% among the things liked best, which compared with 6% that mentioned "other software" among the things they liked the least. (Note: Although this study discouraged the use of "standard" software, teachers sometimes gave their students access to educational games during lunch hours, after school, or for short periods during class time.) References to word processing and writing stories, ranked equally at 14% on the best and least list. (Note: Students tended to use the terms "word processing" and "writing stories" quite interchangeably; hence the distinction between the two is arbitrary - and perhaps misleading).

Students were eager to experience a variety of activities and several commented towards the end of the school year that they "were getting tired" of doing only turtle geometry. This was particularly true for students who had been in the study for two years. When students were asked at the end of each of the two years "What would you like to be able to do on the computer if you have a choice?" a wide range of activities emerged, especially at the intermediate-level: 17% of the primary, 45% of the junior, and 34% of the intermediate-level students expressed a desire to play games (Table 35). Logo was chosen by 53% of the primary, 19% of the junior, and 23% of the intermediate-level students. Of the intermediate-level students, 27% expressed a desire "to make" something, such as a "game to sell" or other "games", as well as making "my own computer language". A few students also mentioned specific things that the computers could do for them. This desire to have the computer as a "servant" may be even more pronounced, since when Grade 3 students in one class were asked at the beginning of the study to draw a picture of their "dream" computer, 50% of the girls and 83% of the boys saw computers in the form of a robot that would serve a variety of their everyday needs, such as:

- feed me; cook for me
- rake leaves; do my work
- pick up my clothes and do the dishes, fetch things
- do my homework.

Many other reactions by students to their computer experience have been presented throughout this report. The three cartoons (Figure 26.3) created by Grade 8 students at the beginning of the study exemplify the main reactions students expressed about learning with computers:

1) It's a fun way of learning.
2) It's a different way of learning.
3) It is essential for future survival in society.

Figure 26.1

Responses at the End of Each Year by Junior- and Intermediate-Level Students to the Statement "I Would Like to Learn More About Computers"

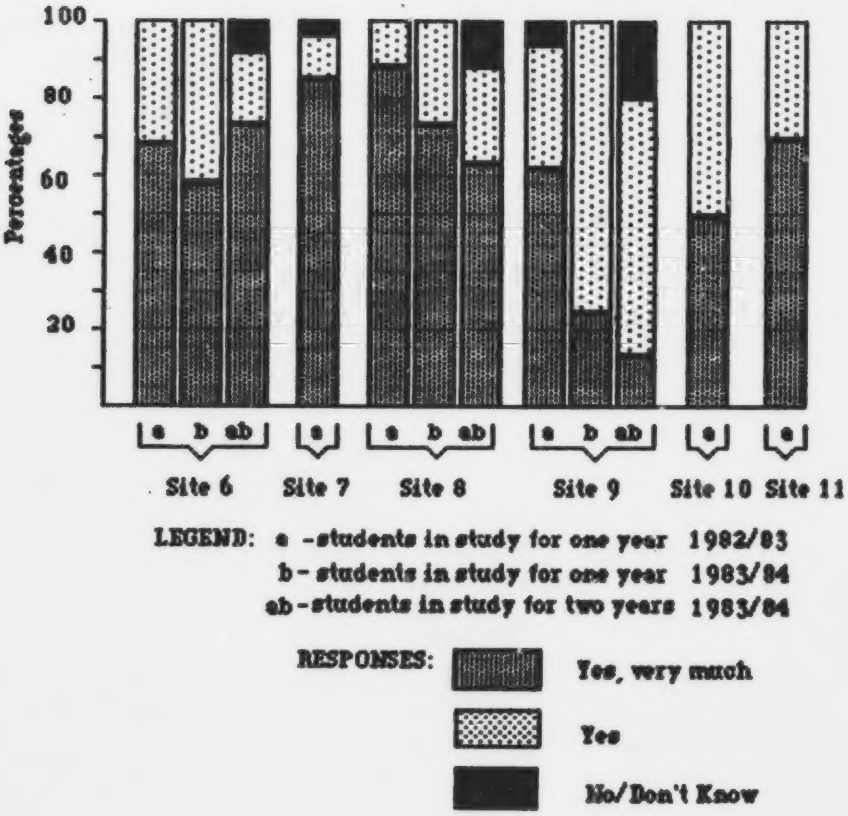


Figure 26.2

Responses at the End of Each Year by Junior- and Intermediate-Level Students to the Statement "Every Student Should Know Something About Computers"

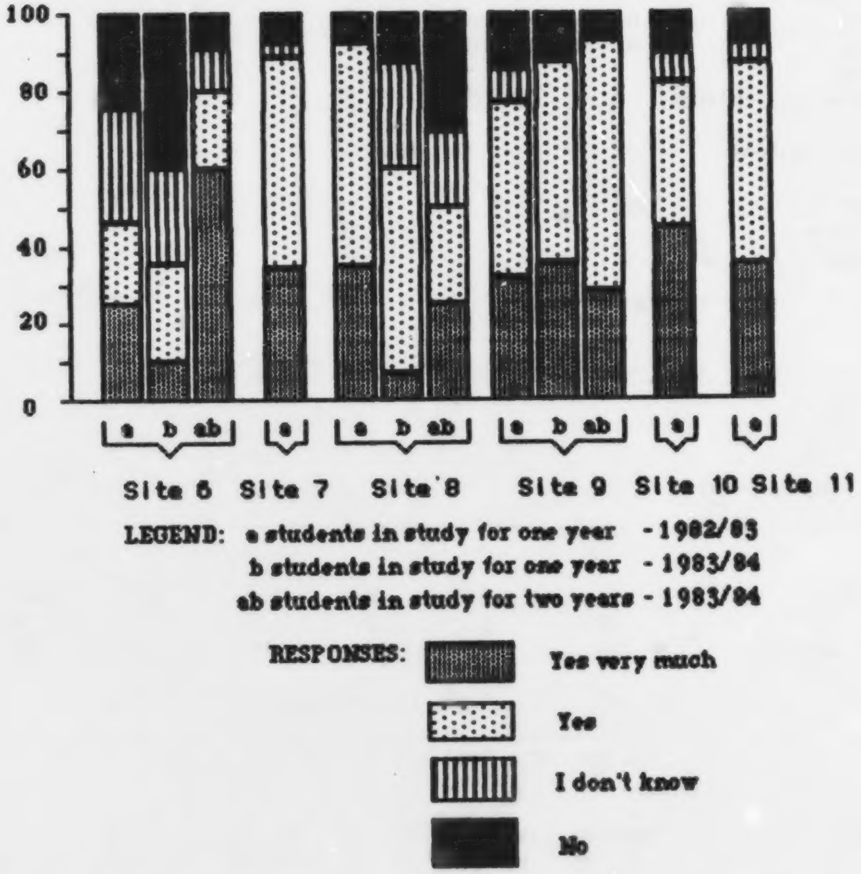


Table 31

Pre- and Post- Questionnaire Responses by Primary/Junior-Level Students to "What kinds of things do you like to do when you are at school?"

Site No.	2a		3a		4a		5a		6a		7a	
Grade	1		1		2		3		5		5	
No. of students	26		17		20		21		25		27	
	Percentages											
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Computer	62	50	18	-	5	15	14	38	28	12	-	60
Gym	4	-	-	-	-	5	14	-	32	44	-	-
Play:in-or outside	8	11	24	29	-	15	-	-	-	8	-	10
Math, numbers	4	8	23	6	65	45	24	32	12	4	15	-
Reading	8	11	6	12	10	5	14	10	-	4	11	-
Writing	4	8	-	12	5	-	10	5	-	4	-	-
Spelling	-	-	-	-	5	-	-	5	8	4	48	-
Art, drawing, colour	-	-	29	29	-	5	24	5	20	12	11	-
SES	-	-	-	-	-	-	-	-	-	-	15	-
Activity centres	-	-	-	6	10	5	-	-	-	-	-	-
Work	-	-	-	6	-	-	-	-	-	-	-	15
Various	10	12	-	-	-	-	-	5	-	4	-	-
Don't know	-	-	-	-	-	5	-	-	-	-	-	-
No answer	-	-	-	-	-	-	-	-	-	4	-	15

Table 32

Pre- and Post- Questionnaire Responses by Junior/Intermediate-Level Students to: "Which of the following subjects do you enjoy the most: English, Foreign Language (French), Art, Science, Gym, Shop & Family Studies, Mathematics, Social Studies Music, Computers, Other (what?)?"

Site No.	6b		6ab		8b		8ab		9b		9ab	
Grade	5		6		7		7		8		8	
No. of students	20		10		14		16		17		13	
	Percentages											
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Computer	50	40	80	30	15	22	32	12	23	12	-	-
Gym	10	35	10	50	14	36	19	44	23	29	39	39
Shop	-	-	-	-	14	14	-	19	6	-	15	-
Art	5	5	10	10	7	14	19	13	24	23	-	-
English	5	-	-	10	7	-	12	-	6	6	15	23
Math	5	15	-	-	7	-	6	6	12	12	15	15
Science	-	-	-	-	22	7	-	6	-	6	-	15
Social Studies	-	-	-	-	-	7	-	-	6	12	8	-
French	-	-	-	-	-	-	-	-	-	-	-	-
Music	-	-	-	-	14	-	6	-	-	-	-	8
No answer	25	5	-	-	-	-	6	-	-	-	8	-

Note: b refers to students in the study for one year (second year of study)
ab refers to students in the study for two years

Table 33

Responses to "Of all the things you have done on the computer what did you like the least?"

	Primary	Junior	Intermed.	Total
Number of respondents	114	84	154	352
	Frequencies			
Comments:				
Nothing	34	16	47	97
Logo:				
turtle geometry	3	11	6	20
a specific design or procedure	32	14	16	62
a specific assignment or challenge	1	1	16	18
edit mode	1	–	5	6
Music	4	1	1	6
making sprites	2	–	–	2
Figuring out angles	–	1	–	1
Using different Logo versions in class	–	–	4	4
list, words	–	–	1	1
Working with SETX, SETXY	–	–	1	1
Word processing:				
Wordprocessor	6	2	25	33
Writing stories	2	14	1	17
Other software:				
Educational games, math games	3	4	7	14
Koala Pad	3	–	*	3
Basic	–	–	3	3
Various:				
Not being able to type	3	2	1	6
Waiting for turn on computer	2	–	–	2
Pushing RESET button	1	–	–	1
Loading up computer	1	–	–	1
Cleaning up disk	–	1	–	1
Not enough time on computer	–	–	2	2
Affective Domain:				
When I make a mistake	3	2	6	11
Doing boring things	2	2	1	5
Not understanding something	–	–	3	3
Getting killed in a game	1	–	–	1
Learning!	–	–	1	1
Not getting help	–	–	1	1
Following instructions	–	–	1	1
Not working with a partner	–	–	1	1
Hardware:				
Running out of space on disk	–	–	6	6
Floorturtle	2	–	–	2
Computer not working	–	1	–	1
Particular computer model	–	–	1	1
Don't know	8	7	2	17

Table 34

Responses to "Of all the things you have done on the computer what did you like best?"

	Primary	Junior	Intermed.	Total
Number of respondents	114	84	154	352
Number of responses **	129	90	172	391
	Frequencies			
Comments:				
Everything	4	9	7	20
Logo:				
Turtle geometry	11	9	42	62
A specific design or procedure	64	9	55	128
Making quizzes, using list procedures	-	-	10	10
Specific assignment or challenge	2	1	5	8
Interactive stories	*	8	*	8
Making sprites	1	3	-	4
The game I made	-	2	1	3
Working with variable procedures	2	-	-	2
Making an instant program	-	-	1	1
Word-processing:				
Using a wordprocessor	2	17	16	35
Writing (better) stories	12	4	2	18
Other software:				
Educ.games	14	2	21	37
Koala Pad, Painter Power	5	20	*	25
Basic	-	1	5	6
Various:				
Typing	1	-	-	1
Affective Domain:				
Finding things out by myself	-	-	2	2
Experimenting; seeing what happens	1	-	-	1
Inventing or learning new things	1	-	1	2
Being in command of something	-	1	-	1
Talking to a computer	-	1	-	1
Giving demonstrations	-	-	1	1
Work with a partner	-	-	1	1
Hardware:				
Using the printer	4	1	-	5
Tasman Turtle	-	2	*	2
Don't know	5	-	2	7

Note: * did not have access to this particular software before the question was asked.

** some students gave 2 responses

Table 35

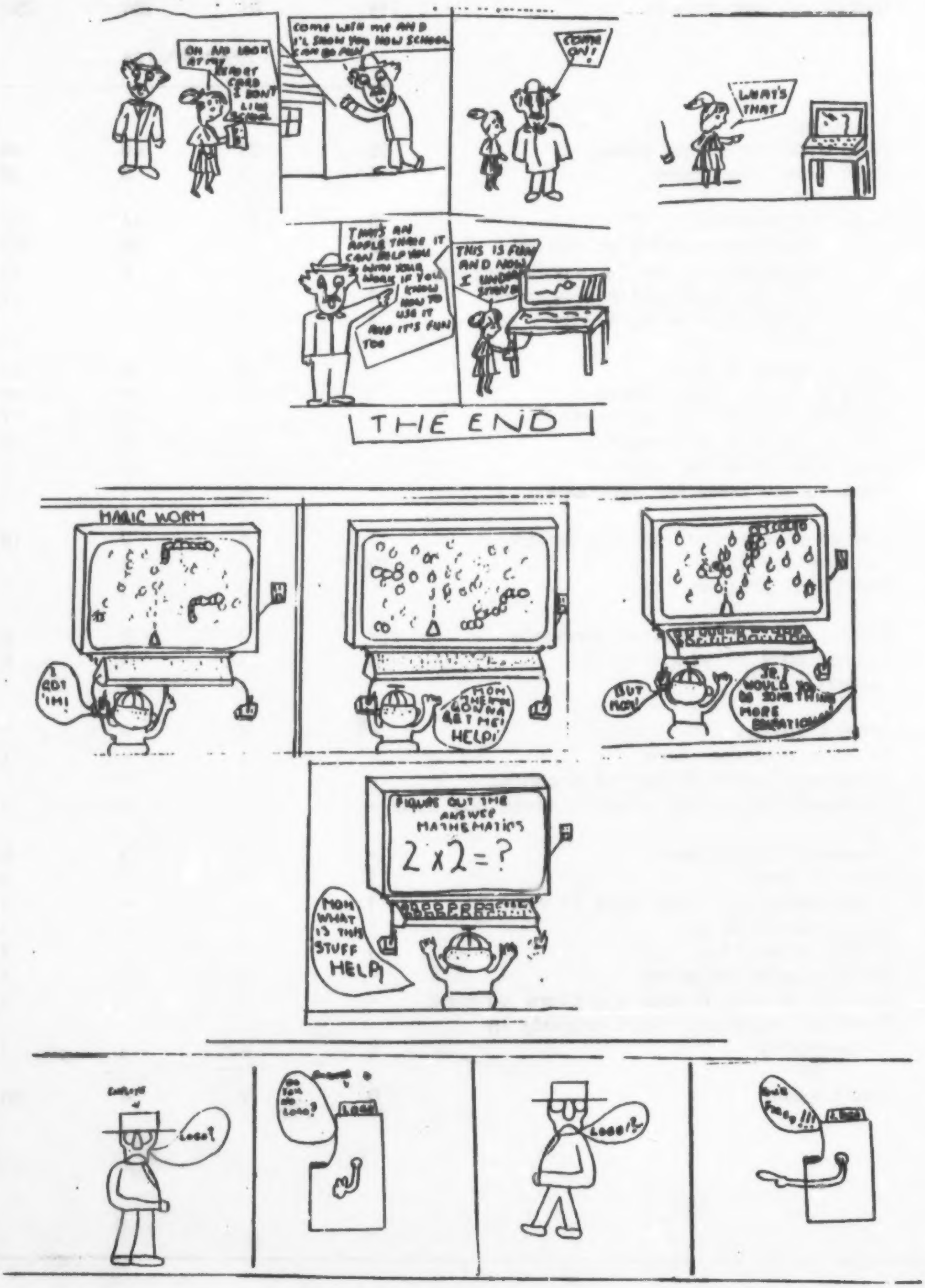
Responses to "What would you like to be able to do on the computer if you have a choice?"

	Primary	Junior	Intermed.	Total
Number of respondents	114	84	154	352
		Frequencies		
Comments:				
Play video or other games	15	35	49	99
Math, spelling games	4	3	3	10
Logo: in general	5	11	16	32
specific picture or design	52	5	10	67
programming; write procedures	1	-	9	10
improve a specific procedure	1	-	-	1
teach Logo to my sister	1	-	-	1
Make a game to sell	-	2	19	21
Make video or other games	1	2	15	18
Make an educational diskette	-	-	1	1
Make a cartoon or animation	-	-	3	3
Make a program for kids	-	-	2	2
Make my own computer language	-	-	1	1
Use wordprocessor; write stories	7	4	7	18
Use the printer	10	-	1	11
Use Paint program	-	3	1	4
Basic, another computer language	-	2	6	8
Music; make it sing	5	-	1	6
Tasman turtle	-	1	-	1
Invent things	-	1	-	1
Write a computer book	-	1	-	1
Experiment with different programs	-	-	1	1
Do something no one else in class has done	-	-	1	1
Homework; schoolwork	-	3	3	6
Make it talk	1	1	-	2
Draw something, then make it real	1	-	-	1
Walk home with me	1	-	-	1
Clean up my room	1	-	-	1
Make it give me money	-	1	-	1
Drop me and my friend any place we want	-	1	-	1
Find out anything about anybody in the world	-	-	1	1
Don't know	9	7	4	20

Figure 26.3

Cartoons by Three Grade 8 Students "Telling a story that involves a computer"

41. "Tell" a story that involves a computer. You can tell the story in words or in the form of a sequence of pictures.



OH NO LOOK AT MY REPORT CARD I DON'T LIKE SCHOOL
COME WITH ME AND I'LL SHOW YOU HOW SCHOOL CAN BE FUN
COME ON!
WHAT'S THAT
THAT'S AN APPLE THERE IT CAN HELP YOU WITH YOUR WORK IF YOU KNOW HOW TO USE IT AND IT'S FUN TOO
THIS IS FUN AND NOW I UNDERSTAND
THE END
MAGIC WORM
I GOT 'IM!
MOM THEY'RE GONNA GET ME! HELP!
BUT MOM!
JR.! WOULD YOU DO SOMETHING MORE EDUCATIONAL!
FIGURE OUT THE ANSWER MATHEMATICS
2 x 2 = ?
MOM WHAT IS THIS STUFF HELP
LOGO?
LOGO
LOGO!?

27. CONCLUSIONS

To summarize all of our findings and to reflect upon their possible implications is beyond the scope of this study. In this chapter, therefore, we focus on only a few of them which are considered most relevant to the current debate on how computers can or should be used and implemented in the schools.

Although the focus in our study was on the computer technology - a technology that is developing and changing so very rapidly - it may be somewhat reassuring to researchers and practitioners to learn that some of the findings are rediscoveries of "old" knowledge, or confirmations of knowledge held by some practitioners and researchers in the field. It is, however, the kind of knowledge that needs to be brought into focus at regular intervals since it often gets lost in the shuffle of meeting the many routine demands of research and of education.

The first of these findings is that teaching - good teaching - at the elementary level is a masterful combination of a competency in a wide variety of subjects, a flexibility in applying appropriate pedagogic strategies, and a deep concern for and sensitivity to the emotional and social needs of children. The teachers in this study demonstrated all of these aptitudes in varying combinations.

The second finding is that what and how children learn very much depends on the teaching/learning environment in which teachers and children have to live and function. Both teachers and children need a supportive environment. The best environment for children seems to be one in which they can explore in a richly stimulating, safe, and accepting environment that offers opportunities for success regardless of their abilities, and does not shut the doors on natural curiosity no matter how advanced or unusual the questions or queries might be.

The third of our findings is that children have strong social needs - but also individual needs. Many children reported that they preferred or enjoyed working with a partner but also reported that they would like to work alone sometimes. A significantly greater proportion of children in classrooms where interaction with peers and adults flowed freely in an atmosphere of dialogue and experimentation, reported a strong boost in their general confidence and self-esteem. It was found that social interaction did not only facilitate a socializing process but was also a critical component in the furthering of cognitive development and of creative expression. This strong need for social contact expressed by children would suggest that any future scenario that sees only the singular child happily engaged in front of a computer over extended periods of time away from any human contact, is either unrealistic or, if it is forced on children, will lead to serious dislocations in their normal development. This finding does not challenge the notion of individualized or independent learning, but it does imply that models for such learning need to incorporate strategies that will facilitate some social interaction among the learners.

A fourth finding is that the principal is a key person in setting the "atmosphere" in the school. A principal who is actively supportive of change, especially in terms of emotional and social support, can greatly lessen the stress or fears that often accompany change or anticipated change. Much greater attention will have to be given to "in-servicing" principals with respect to the various uses of the technology and how these affect educational and implementation strategies within the school.

A fifth finding which one might hope will not be rediscovered over and over again, is the potential differential impact that technology has on boys and girls. There is strong evidence from an intermediate-level class that Logo and computers are not immune to the sex bias that mathematics, science, and other forms of technologies have generated. Strategies to remove or lessen this bias within the classroom or school setting (and possibly through the advertising medium in order to get at deeply-rooted cultural bias) need to be explored.

One finding which confirms more the convictions of the critics of public education than its proponents, is that children have a tremendous untapped potential for learning. All the teachers in our study had been surprised at how much children of all abilities and age levels were able to learn - they were able to discover this because they had the opportunity to look at children interacting with computers, unencumbered by curricular expectations and accountability. This significantly altered their way of "seeing" children as learners: old assessments and categorizations of children broke down and old teaching strategies were being reassessed. They discovered that children did not learn only by incremental steps from simple to more complex ideas but often worked "backwards" from the more complex. Such an approach has really been the primary learning strategy for children from birth on, since "life" consists of many diverse stimuli and of dealing with many advanced verbal and cognitive concepts from which children draw patterns, make connections, and build their own knowledge. Through this process, they learn a myriad of intricate and complex skills and knowledge before they enter school. Teachers also found that many children working with turtle geometry explored with a particular 'primitive' or concept over and over again. Some looked for patterns out of such explorations quite aggressively, whereas, others appeared to be less engaged in such a search. Teachers found great variations in how quickly children grasped certain instructions or concepts on the computer. One Grade 1 teacher expressed a "feeling" that if children could not grasp an idea within the first fifteen minutes they weren't ready for it. She began to reflect on how much time might be wasted in schools by teaching things either too early or too late for individual learners. Whether there are individual "learning curves" in discovering patterns (or more complex concepts, hypotheses, or theorems) or whether there are appropriate strategies to foster this process could not be answered by this research. Hart (1978) has put forward a theory of human learning based on findings from brain research that gives credence to this type of learning approach. He defines the process of learning as:

> ... the extraction of meaningful patterns from confusion. What we call "insight", seemingly very mysterious, appears to be simply the recognition of the key patterns that apply to a situation or problem. (p. 42)

He goes further to state that in order to extract patterns from the confusion of the real world, children must have a great deal of input; input of things that are similar and input of things that are different. (Note: much of our research could be described in these terms). The order in which this appears, he claims, does not really matter. Through this process, mental "programs" are constructed and stored in the brain that subsequently can facilitate appropriate action or be used for further learning. He further suggests that "ordering, scolding, punishing, giving a low mark - none of these will enable children to use programs they don't possess" (Hart 1978; p. 45). Our study has shown that the computer can significantly increase the quantity of input-output connections that a child can observe within a given time span. This speed of receiving feedback to any given input was extremely important to the children, and central to the "holding" power that activities on the computer often have on children. The fast feedback was also beneficial for the teachers because they were in a better position to observe the "thinking process" of a child, and the emotional reactions to various events while the child was engaged in a particular activity. Teachers were thus given quick insight into a child's cognitive style which in turn made it easier for them to give the child appropriate guidance.

There is strong evidence from our study that the extensive exploration and experimentation within Logo made it possible for some children to give personal meaning to what they have learned and not regard it as merely a collection of facts that have little or no personal relevancy. Papert (1980) set out three attributes for mathematics which need to be met in order to bring it into a personally meaningful context for the learner:

1) the mathematics must be continuous with well-established personal knowledge from which it can inherit a sense of warmth and value as well as 'cognitive' competence;
2) it must empower the learner to perform personally meaningful projects that could not be done without it;
3) the topic must make sense in terms of a larger social context. (p. 54)

Many children were able to experience certain aspects of mathematics, programming, and problem-solving within a turtle geometry environment in such a fashion (different aspects for different children). Our research has shown that Logo, coupled with an environment in which the teacher skillfully blends direction with experimentation, makes it possible for young children to learn certain concepts in mathematics, programming, and problem-solving that are traditionally not introduced until high school. This strongly suggests that the creative uses of computers will dramatically change axisting curriculum content and blurr the delineations based on age. To assess the full impact on what children are capable of learning in such a computer-based creative environment is not possible until children can be observed in such environments and as they progress through the school system. The fact that teachers in this study found it extremely difficult to create a learning environment that fosters creativity within existing school and curricular structures also strongly suggests that research is required into how and what children learn when existing structures are modified or removed. Although "idea" booklets on how to connect the computer with present curriculum content can be of great benefit to both teachers and students, any attempt to tie such resources to any given grade level, and to restrict explorations with Logo or other software to activities that are currently considered to be appropriate for a stated grade level, would incapsulate the computer technology before its potential for learning could be explored.

Our study found that teachers who were able to change their classrooms into an environment that encouraged creative expression, had to examine very fundamental assumptions about teaching, learning, and their professional role as teachers. They found this to be a very difficult process. The fact that such experienced teachers felt greatly constrained by existing structures in changing the classroom and teaching routine and strongly felt that they were on a new adventure in attempting to do so, shows that the existing school structures (both physically and mentally) are not well suited to foster creative expression. The literature on creativity and the gifted is filled with examples that illustrate how poorly schools can accommodate more than minimal deviations from a "norm," and how expressions of original thought by children threaten teachers. Torrance in his book Guiding Creative Talent (1962) shows how important a nurturing environment is if creativity is to flourish and how readily it can be destroyed:

> Evidence from both cross-sectional and longitudinal studies of the development of the creative thinking abilities suggests that many highly creative children, at almost any age, sacrifice their creativity by repressing their creative needs and abandoning creative activities. For some children, this occurs during the Kindergarten period. With favourable conditions in the primary school, some of them recover, but apparently some do not. The next really serious period of abandonment occurs near the end of the fourth grade. Again, some recover while others apparently sacrifice their creativity permanently. The third period of decline occurs at about the time the individual enters junior high school, and another occurs near the end of the high school period. (p. 125)

If teachers are to foster creative expression among the children they teach, they also must be allowed to express, get in touch with, or rediscover their own creative drives. In order to do so, they must have a safe and accepting environment that firstly acknowledges and addresses their fears, and secondly encourages them to experiment and explore. Such environments may not necessarily be computer-dependent. Teachers in this study, however, have found it relatively easier to create such an environment for themselves and their students with computers in their midst. Two teachers, one a primary-and one a junior-level, while anticipating the end of the study, recorded the following in their logbooks:

> It's almost over! Once you've flown, you really hate to walk! Right? Is it possible for a teacher to regress to a pre-computer state (after two years) without serious consequences?. Answer: NO. (Feb. 14/84)
>
> I think the fact that the computers are going and I have had so many positive comments from parents makes me a bit frustrated. Was it all worth it? I know next year, with only two computers in the school I will be lucky to have one, even one day a week. Still, I suppose "It is better to have loved and lost than never to have loved at all"! (March 6/84)

However, just as "teaching without a curriculum" does not mean "simply leaving the child alone", it also does not mean "simply leaving the teacher alone". It means supporting the teachers as "they build their own intellectual structures with materials drawn from the surrounding culture" so that they in turn can help their students to build theirs. Some of the supports suggested by teachers in this study involve opportunities to learn (both courses and time), more resources (access to consultants, books, manuals, magazines), more sharing among peers, more encouragement from their principal, and more guidance with respect to Logo and other creative uses of computers.

One additional finding that is of great significance to researchers and to those evaluating software is that the nature of the teaching/learning environment strongly shapes what students learn. In order to assess them fairly, findings on Logo or other software will have to be based on a careful description of the teaching/learning environment. Merely stating that "students used Logo for six weeks" is not sufficient. A description of the teacher's attitude towards Logo, the teacher's intended use of Logo, the actual hands-on time by students, the social climate in the class, and any pertinent activities outside the class need to be documented and become an integral part of any finding or evaluation.

Appendices

A. Tables Giving Detailed Results of Questions on the Junior/Intermediate Logo Quiz

TABLE 36: RESULTS OF LOGO QUIZ FOR JUNIOR/INTERMEDIATE LEVEL STUDENTS QUESTIONS: 1 AND 2

QUESTION 1: The turtle starts at position A (HOME), follows the given instructions and ends up at point B (see sketch). The turtle wants to get back to point A along the dotted line. Write down the necessary instructions

a) FD 50 RT 90 FD 100 RT 90 FD 50

b) REPEAT 18 [FD 5 RT 10]

QUESTION 2: Write a procedure - using REPEAT statements if possible - for the following shapes:

a) Square b) Pentagon c) Octagon d) Staircase

Site No.	5b	6a	6b	6ab	7a	8a	8b	8ab	9a	9b	9ab	11a
Grade	3	5	5	6	5	6/7	7	7	7/8	8	8	8
No. of students	21	26	20	9	30	25	14	12	32	16	13	28
	Numbers in Percentages											
1a) correct	67	85	65	89	27	92	64	80	76	69	69	68
1b) correct	86	62	50	44	20	84	79	9C	65	50	54	65
2a) Square:												
Procedure correct												
Repeat correct	90	81	70	100	0	100	93	100	72	81	100	100
Pattern correct	100	92	85	100	3	100	93	100	72	81	100	89
Both correct	90	81	60	100	0	100	93	100	66	75	100	89
No attempt	0	0	0	0	17	0	0	0	19	0	0	0
2b) Pentagon:												
Procedure correct												
Repeat correct	86	73	50	100	0	100	93	100	78	69	54	96
Pattern correct	19	0	0	0	0	20	7	20	41	6	12	14
Both correct	19	0	0	0	0	20	7	20	38	6	12	14
No attempt	0	4	0	0	37	0	0	0	19	25	34	4
2c) Octagon:												
Procedure correct												
Repeat correct	86	81	40	100	0	100	79	100	72	76	62	82
Pattern correct	24	54	25	56	7	72	43	80	47	12	34	39
Both correct	24	42	20	56	0	72	43	80	47	6	34	39
No attempt	0	4	0	0	43	0	0	0	19	12	38	7
2d) Staircase:												
Procedure correct												
Repeat correct	38	38	30	44	0	76	14	90	56	56	54	64
Pattern correct	5	12	15	22	4	44	36	70	19	38	54	39
Both correct	0	4	10	22	0	44	7	60	19	12	38	39
No attempt	0	0	0	0	53	0	0	0	19	6	12	4

TABLE 37: RESULTS OF LOGO QUIZ FOR JUNIOR/INTERMEDIATE LEVEL STUDENTS QUESTION: 3

Question 3: Start in the HOME position. Sketch the shape the turtle would make if it followed the instructions below. Improve or correct the instructions where ever possible.

```
        a) LT 30 FD 80 LT 120 FD 80 LT 120 FD 80
        b) REPEAT 5 [FD 40 RT 90 FD 60 RT 90]
        c) REPEAT 100 [FD 10 RT 5]
        d) TO HILLTOP :SIDE
           REPEAT 4 [FD :SIDE RT 90]
           HILLTOP :SIDE-5
           END
```

Site No.	5b	6a	6b	6ab	7a	8a	8b	8ab	9a	9b	9ab	11a
Grade	3	5	5	6	5	6/7	7	7	7/8	8	8	8
No. of students	21	26	20	9	30	25	14	12	32	16	13	28
	Numbers in Percentages											
3a) Triangle:												
sketch correct	90	46	55	100	17	96	57	40	34	44	38	50
improvement correct	0	0	0	0	0	0	0	0	0	0	0	0
No attempt	5	4	5	0	7	0	0	0	38	0	31	4
3b) Rectangle:												
sketch correct	57	54	50	100	0	64	71	80	69	81	69	64
improvement,correct	0	4	0	40	0	16	7	30	0	19	15	7
No attempt	5	0	0	0	63	0	0	0	25	0	0	0
3c) Circle:												
sketch correct	43	27	5	100	7	52	50	40	28	38	46	36
improvement, correct	0	0	0	0	7	12	0	20	0	0	0	4
No attempt	24	8	35	0	77	20	21	10	38	12	54	7
3d) Recursive squares:												
sketch correct	0	8	0	10	0	32	7	30	0	0	0	18
improvement, correct	0	0	0	0	0	8	0	0	0	0	0	0
no attempt	29	54	75	33	100	32	29	30	100	81	100	21

TABLE 38: RESULTS OF LOGO QUIZ FOR JUNIOR/INTERMEDIATE LEVEL STUDENTS QUESTIONS: 4 AND 6

QUESTION 4: Write a procedure, using variables, so that you can use this procedure to draw the following shapes in different sizes:
(a) a square:
(b) a rectangle:

QUESTION 6: If the procedure WIBBLE is defined as

```
TO WIBBLE :N :L :A
   REPEAT :N [FD :L RT :A]
END
```

a) Sketch what the turtle will draw for WIBBLE 6 50 60
b) Give the values of :N :L :A for WIBBLE to create a square.

Site No.	5b	6a	6b	6a	7a	8a	8b	8ab	9a	9b	9ab	11a
Grade	3	5	5	6	5	6/7	7	7	7/8	8	8	8
No. of students	21	26	20	9	30	25	14	12	32	16	13	28
	Numbers in Percentages											
4a) Square with variable:												
proc.format correct	67	-	55	80	-	-	47	83	-	6	0	-
Repeat 4[..] correct	86	-	20	60	-	-	60	75	-	35	7	-
use one var. correct	81	-	40	70	-	-	67	83	-	6	0	-
all correct	62	-	15	60	-	-	27	67	-	0	0	-
no attempt	9	-	20	0	-	-	13	8	-	35	86	-
4b) Rectangle with variable:												
proc.format correct	71	73	10	66	0	100	43	70	9	19	0	86
Repeat 2[..] correct	14	4	5	44	0	60	21	80	6	19	0	29
use one var. correct	33	12	5	0	0	28	21	50	0	0	0	50
use two var. correct	0	0	5	33	0	36	36	40	0	0	0	11
individual commands	0	19	0	0	13	8	7	0	28	19	0	7
all correct	0	0	0	33	0	52	21	50	3	0	0	32
will draw rectangle	19	8	35	33	0	52	29	50	3	38	0	32
No attempt	10	4	25	0	83	4	21	0	44	47	93	7
6a) WIBBLE 6 50 60:												
sketch correct	48	0	10	78	0	44	35	70	3	6	0	39
no attempt	14	58	45	0	100	28	7	0	84	82	100	18
6b) WIBBLE, square:												
:n :L :A correct	76	19	15	56	0	84	64	90	16	12	0	50
no attempt	19	62	50	33	100	12	14	0	84	88	100	22

TABLE 39: RESULTS OF LOGO QUIZ FOR JUNIOR/INTERMEDIATE LEVEL STUDENTS QUESTION: 5

Question 5: Write a procedure, using sub-procedures if you can, for the following shape:

Site No.	5b	6a	6b	6ab	7a	8a	8b	8ab	9a	9b	9ab	11a
Grade	3	5	5	6	5	6/7	7	7	7/8	8	8	8
No. of students	21	26	20	9	30	25	14	12	32	16	13	28
	Numbers in Percentages											
top procedure	29	8	5	11	0	56	43	83	0	0	0	50
all sub-procedures	20	8	10	22	0	28	29	8	0	0	0	14
some sub-procedures	10	15	10	34	0	12	7	0	3	0	8	4
indiv. commands	29	58	15	22	10	0	7	0	41	19	16	25
two circles correct												
with variable	10	0	0	0	0	12	0	25	0	0	0	7
without variable	29	15	25	34	0	16	21	67	3	12	7	11
position correct:												
left ear	10	19	10	56	0	4	14	25	0	6	0	11
right ear	5	11	0	11	0	4	7	17	0	6	0	14
hat	0	0	0	11	0	12	0	17	0	12	0	22
all correct	0	0	0	0	0	4	0	8	0	0	0	0
no attempt	10	19	55	11	90	4	14	0	56	81	76	7

B. Individual Site Descriptions

CLASSES USING A COMPUTER LABORATORY

SITES 1a, 3a, 4a, 7a and 11a: MOUNTAIN PARK PUBLIC SCHOOL

The School

Mountain Park Public School is a modern, well equipped, Kindergarten to Grade 13 school that offers vocational as well as academic subjects. In the year of the study, the school had an enrollment of 534 students, including 293 elementary students, 174 secondary students, and 67 adults who attended evening classes. It is located in a small village and draws its students from a large, economically depressed, rural area.

The elementary division had a staff of eleven classroom teachers and support staff that included physical education, French, vocal music, guidance, and library teachers.

M.P.P.S. has been using microcomputers since the fall of 1980, when they acquired two APPLE II+ computers. In the fall of 1981, M.P.P.S became the site of a Ministry of Education Software Pilot Project, and acquired seven additional units. By the fall of 1982, they had sixteen APPLE computer systems and three printers. Thirteen of these computers were in a computer lab, one was used by the administration, and two were rotated among the elementary classrooms.

M.P.P.S. students and staff, working under Experience '81 and '82 grants, have catalogued and written abstracts for the more than 600 computer programs available at the school.

The principal, Mr. Quick, was most supportive of computer use, and had been instrumental in obtaining Ministry funding for the Software Pilot Project.

The Computer Laboratory:

This laboratory consisted of a large rectangular classroom with a small glassed-in room behind it that doubled as a typing room. The large room was fully furnished with large tables. Seven computers were arranged on tables along the back and one side wall of the room. The small room had six computers along a side and end wall, and six typewriters along the other wall. A high speed printer and one Epson printer were in the smaller room. A magazine rack displayed current issues of computer magazines.

The Class - Site 1a:

This was a Kindergarten class of 24 students, 4 boys and 20 girls, aged four and five. Mrs. Greer described her class as an advanced Kindergarten; however, she had one little girl who was a behavior problem. Only one child, who had a computer at home, had had previous experience using a computer. The teacher had a regular parent volunteer and occasionally older students volunteered to assist in the computer room. Without their help, she felt she could not have managed.

The Teacher - Site 1a:

Mrs. Greer had been teaching Kindergarten and Grade 1 for two years. She has a strong instrumental music background and made music activities an important part of her program. She organized her lessons around integrated themes. The classroom had beautifully equipped centres for play.

During the year prior to the study, Mrs. Greer had a computer in her classroom full-time and used drill and practice software. She started using Logo with her class in the spring. Mrs. Greer taught the Kindergarten class one full day every other day. On the other days, she worked in the teacher's workroom using Logo with pairs of students from the primary division. They worked in eighty-minute sessions.

She attended a Logo workshop at Queen's University in the winter of 1982 and had been to several Logo sessions at the annual Educational Computing Organization of Ontario (ECOO) conference.

The Class - Site 3a:

There were 21 students in this class, 9 girls and 12 boys, whose ages ranged from five to eight. They were described as a slow Grade 1. Miss Gagnon considered only twelve of the students to be working at or near grade level. Eight were readiness students (not ready for Grade 1), and six attended special education classes for half the day. There were many health and behaviour problems in the class as well.

Most of the students had used an APPLE II+ computer with drill and practice software during their Kindergarten year.

The Teacher - Site 3a:

Miss Gagnon had been teaching Grades 1 and 2 for the previous seven years. She has a music background (piano), and a particular interest in special education.

During the year preceding the study, Miss Gagnon had used an APPLE II+ computer in her classroom for one-hour periods once a week. Most of that time was spent on drill and practice software, such as Milliken Math. She attended a half-day workshop on Logo at Queen's University in 1982, and during the year of the study was enrolled in a computer course at her school to learn BASIC and word processing.

The Class - Site 4a:

This Grade 2 class had 22 students, 13 girls and 9 boys ranging in age from six to ten years. Four students were considered to be above average in ability, three were on special education withdrawal programs for reading, and two were well below grade level in mathematics. Mrs. Kroeker described them as a very co-operative class, with no personality or behaviour problems.

All but two of these students had used a computer with drill and practice software in the previous grade. A few were briefly introduced to Logo in the spring prior to the study. Three of the students had computers at home.

The Teacher - Site 4a:

Mrs. Kroeker had previously taught Kindergarten to Grade 6. Her areas of special interest were math, French, and physical education.

Mrs. Kroeker had used an APPLE II+ computer with a Grade 3 class a year prior to the study. In that class, she used one computer every morning and each student used it for between forty and sixty minutes each week. Towards the end of that year, she made extensive use of Logo.

Prior to the study Mrs. Kroeker took part in two workshops at her school that introduced her to various educational software. She also attended an afternoon in-service session on Logo at Queen's University and several Logo workshops at the annual conference of the Educational Computing Organization of Ontario. During the course of this study, she took a credit course in Pascal at Queen's University, and a BASIC and word processing course at her school.

The Class - Site 7a:

This was a Grade 5 class of 32 students, 16 boys and 16 girls, aged nine to eleven. All but two of the students had used a computer for drill and practice software in the previous grade. Two students had a computer at home.

The Teacher - Site 7a:

Mr. Crawford was an experienced teacher who had taught all grades from six to twelve. His areas of expertise were language arts and science.

He had had limited experience with microcomputers, but was very enthusiastic about the possibilities of their use in education. He had taken a two-day workshop on computer literacy at his school and had attended a brief workshop on Logo at Queen's University.

Mr. Crawford used some drill and practice software with his students during the year prior to the study, but had not taken his class into the computer lab. He did not take any computer related courses during the year.

The Class - Site 11a:

This was a Grade 8 class of 32 students, aged thirteen and fourteen. There was an even distribution of boys and girls. Mr. Lorton described his class as above average in ability. They were the top achieving thirty-two students out of a group of fifty. The majority of the students had previously used computers at school. None of them had computers at home.

The Teacher - Site 11a:

Mr. Lorton had seventeen years of teaching experience in Grades 3 to 12. He has Honours Specialist qualifications in mathematics and English.

During the year of the study, he taught math, science, and language arts to his Grade 8 home-room class, science and literature to a Grade 7 class, and English to a Grade 11 class.

The year prior to the study, Mr. Lorton had used the computer laboratory with a Grade 8 class for forty minutes each day. The students used drill and practice software, a word processing program called "Magic Window", and learned BASIC programming. Mr. Lorton had taken one computer literacy course at his school.

SITE 10a: DEMPSTER PUBLIC SCHOOL

The School:

Dempster Public School is a Kindergarten to Grade 8 school with an additional French-immersion program for Grades 5 to 8. The students in that school come from a wide area that encompasses both urban and rural residences.

The principal of this school had a positive attitude toward microcomputers and was open to exploring their possible uses in the learning/teaching process. There was only one teacher in the school who had attended a computer workshop and who had worked with computers prior to this study. None of the teachers had any knowledge of Logo.

During the first year of the study, however, the principal and three other teachers took a Logo in-service course offered by their school board. The school purchased two computers at the beginning of the year and the principal used these to give in-service sessions to other teachers. He also encouraged his teachers to take their students to his board's computer resource centre as often as possible.

The Computer Laboratory:

The computer laboratory used by this class was located at Queen's University. At the time of the study it housed twelve APPLE II+ computers and two printers. Students, accompanied by one of their regular classroom teachers, came to the computer laboratory once a week for a 2 1/2 hour period over a period of four months.

The Class:

The group studied was a Grade 8 French-immersion class. There were 17 students, 11 girls and 6 boys, between the ages of twelve and thirteen, all of whom were considered to be above average in academic abilities.

Of the 17 students in the group, three had some previous computer experience in BASIC. Of these three, only one had attended a class on computer programming and had written more than 10 computer programs. None of the students had any Logo experience before they started in this project.

The Teacher:

The teacher in charge of this group was David Nesbitt, who was a consultant from the school board. The regular classroom teachers - Carl Knoll, the English teacher, and Ruth Quincy, the French teacher - alternately came with this class to the computer room to observe. During their visits, they interacted freely with the students, asked questions, but did not do any direct teaching.

David Nesbitt had taught Grades 4, 5, 6, 7, and 8. During the past six years he had been a consultant for the primary-junior division at his school board and during the last two years, he served as consultant for education of gifted students as well. He served on his board's committee on Computers in Education. His areas of special interest and expertise were science, social studies, mathematics, language arts and he listed among his hobbies "teaching courses".

Mr. Nesbitt's interest in computers was ignited by Seymour Papert's book Mindstorms. He participated in a graduate seminar on Logo in September of 1981, and he took a seven-week workshop on Logo in the spring of 1982. Both of these were taken at the Faculty of Education at Queen's University. Mr. Nesbitt was less interested in Logo as a computer language and preferred to explore the nature of a "Logo experience". He therefore requested access to someone with programming expertise and it was agreed that Mrs. Carmichael, one of the researchers and Mr. Boyle, the co-ordinator of the computer laboratory would be available for consultation both within and outside the classroom. Mr. Nesbitt gave only minimal direction to his students and preferred to respond to questions as they arose.

CLASSES USING COMPUTERS IN THE CLASSROOM

SITES 2a and 2b: ROSE FULLERTON PUBLIC SCHOOL

The School:

The school was a typical Kindergarten to Grade 8 school in a mixed socio-economic neighbourhood. At the time of the study there were 300 children and a staff of 15.

In September 1982, at the beginning of the study, the school owned one PET computer which was stored on a shelf in the supply room. In addition, Mrs. North, the Grade 1 teacher who participated in this study, and Mrs. Ingram, the Kindergarten teacher, used their personal APPLE II+ computers in their classrooms. No one else in the school had any particular involvement with computers and took little interest in the computer activities in the Kindergarten and Grade 1 classes.

During the first year of the study, the principal became much more interested in computers and at the end of the year a committee of parents initiated a fund-raising drive for the purchase of computers which yielded approximately $3,500. An APPLE II+ computer was purchased for the Grade 2 classroom so that the children, who already had had two years with computers, could continue to work in Logo. In addition, two TRS 80 computers were purchased for the intermediate division. The PET computer began to be used by the intermediate division during the second year.

The Class - Site 2a:

The class observed at this school was a Grade 1 class of 27 students, 17 girls and 10 boys, aged five and six. The ability range within the classroom was typical of other classes. All of the students had had the opportunity to use Logo on an APPLE II+ for approximately two months in Kindergarten towards the end of the previous year. Their teacher, Mrs. North, had also been their Kindergarten teacher.

The desks in this classroom were grouped in clusters. There were specific activity centres in various parts of the room. The computers formed two such activity centres. Gentle quiet movement was allowed within the classroom.

This project provided the class with one TEXAS INSTRUMENT 99/4A computer with a Logo sprite implementation. (Sprites are multiple moving objects or "turtles" whose colour, speed, and direction can be changed simultaneously). There was no printer for this computer. In addition, the teacher used her personal APPLE II+ computer and a Terrapin Logo implemention in the classroom. In November, Mrs. North added a PET computer which belonged to the school.

During the year, Mrs. North had a "grandmother" come to the classroom one day a week to read to the children. She also made extensive use of parent volunteers in her classroom.

The Class - Site 2b:

During the second year of the study, there were 24 students in this class, 17 boys and 7 girls. One of the boys was severely handicapped and moved in a wheelchair. The classroom arrangement was similar to the previous year with the desks grouped in clusters around the room. The computers again formed two of the activity centres and the students were free to go to them whenever there was an empty chair. The majority of the students had used an APPLE II+ computer during their previous year in Kindergarten.

There were four computers and one printer in the classroom for most of the second year: one APPLE II+ and two TEXAS INSTRUMENT (TI) 99/4A computers supplied by the study, and Mrs. North's personal APPLE II+ computer. In December, the school bought a Koala Pad which was used extensively in that class. One of the APPLE II+ computers was fitted with special attachments for Colin, the student with cerebral palsy. Students used the TEXAS INSTRUMENT computers for Logo sprites and the APPLES for Terrapin Logo.

There were two teaching assistants in the classroom, Ms. Logan who was responsible for Colin, and Ms. Dewhurst who worked in the class with three students who had behaviour problems. Ms. Stott, a supply teacher, was in the class for ten weeks during the winter when Mrs. North was absent.

The Teacher - Site 2a and 2b:

Mrs. North had been teaching for ten years having had taught Kindergarten to Grade 4, and special education, and had served as primary education consultant for her board for two years. Her areas of expertise and special interests were music, art, language arts, mathematics, physical education, and Logo.

Mrs. North had worked with computers for approximately six months prior to the beginning of the study. She took a course in Logo in the spring of 1982, following this with the Computers in the Classroom Part I in 1982/83, and Part II in 1983/84. All of these courses were offered at Queen's University, 80 km from her home. In September 1983 she was selected to take a computer course given by the Federation of Women Teachers. She also had spent considerable personal time exploring ideas on the computer. She had purchased her own APPLE II+ which she used in her classroom. During the previous two summers she also had offered a series of Logo workshops at her home to students, aged six to fifteen. One purpose for doing this was to raise money for the purchase of an additional computer for the school.

In November 1982, Mrs. North and Mrs. Ingram started a noon-time computer club which met once a week and was open to all grades. A computer club was again started in the fall of 1983 but only met a few times, as Mrs. Ingram took a leave of absence after Christmas and Mrs. North was unavoidably absent for ten weeks in the winter.

In February 1983, Mrs. North and Mrs. Ingram were invited to give a workshop to a neighbouring school board on the use of computers in the primary grades.

SITES 5a and 5b: LEASIDE PUBLIC SCHOOL

The School:

Leaside Public School is a rural school with pupils from Kindergarten to Grade 8. Almost all the students were brought to school by bus. During the course of the study there were 470 students in the school and a staff of 27.

At the beginning of 1982, the local school board gave a Logo Workshop at Leaside Public School. This introductory workshop was attended by five staff members and the principal and vice-principal. Ms. Cameron (the teacher participating in the study) and Ms. Johnston (the Grade 6 teacher) subsequently enrolled in an introductory Logo course at Queen's University. The intermediate-level mathematics teacher, who had done some work with Telidon, was the only other teacher in the school who had worked with computers prior to the study. During 1983 three teachers enrolled in the TV Ontario course "Bits and Bytes".

In the summer of 1983 three teachers, (Grades 6/7, 6, and 1/2) took the Computers in the Classroom Part I course, taught by Ms. Cameron, and two more enrolled in the same course during the winter. The principal of the school took this course during summer of 1984.

During the first year of the study, two classes were using Logo, Grade 3 and Grade 6. In January of the second year, students from the intermediate special education class came to the Grade 3 classroom for one forty-minute period, four times per each six-day cycle to learn Logo from the Grade 3 students.

In September 1982, the school owned one APPLE II+ computer and one Terrapin Logo system which was used exclusively by the Grade 6 class; no other teacher had shown any interest in using it. In the fall of 1983, the school acquired one APPLE IIe and a printer. During the 1983-84 school year there were five teachers besides Ms. Cameron who used computers extensively in their classrooms.

The Class - Site 5a:

There were 22 students in this Grade 3 classroom, 12 boys and 10 girls, ranging in age from seven to nine. Generally, they were from average to low-average in ability. Prior to this study, only five of the students had seen a computer or knew anything about them. Two of the students indicated that they had an ATARI computer at home. None of the students had any experience with Logo.

The classroom was large and bright with students' work decorating the walls. The desks were in neat rows facing the front blackboard. The computer - an APPLE II+ - and a printer, both provided by the study, were on a table at the back of the classroom between the silent reading corner and the teacher's desk. This class also received copies of Terrapin Logo and Bank Street Writer.

The Class - Site 5b:

In this class there were 23 students, 11 boys and 12 girls. Ms. Cameron described them as a "much brighter" group than she had had the previous year; however, they were not all above grade-level. Nine of the students were rated as high achievers, ten as average, and four as slow learners. One child had a computer (VIC 20) at home at the beginning of the year; one other child had used a computer before.

Students' desks were arranged in three double rows facing the front of the room. There were three study areas at the front of the room, one for a computer, and the other two for typewriters. A second computer and printer were on a table at the back of the room in front of the teacher's desk. A small carpeted area at the back of the room served as a quiet reading area. The room was well equipped with art and reading materials. Both computers (APPLE II+) and a printer, as well as a Terrapin Logo and Bank Street Writer software package, and two commercially published books on Logo were provided by the project. In January, a Koala Pad was added to the classroom.

The Teacher - Site 5a and 5b:

Ms. Cameron was a very experienced teacher who had taught Grade 3 for the past five years. Prior to this, she had spent many years teaching in the intermediate division. She had also been an intermediate resource teacher and had given workshops in various areas of mathematics.

Ms. Cameron first heard about Logo in January 1982 when she took a workshop on Logo held in her school. She subsequently enrolled in a Logo course and a Computers in Education Part I and Part II at Queen's University. Prior to the study, she had had a computer for five months in her classroom and her students used Logo during that time.

During the 1982 school year, Ms. Cameron had a parent volunteer assisting her in the classroom one day a week. From November onwards, her principal arranged for her to have one free forty-minute period in each six-day cycle and a school's computer so that she could work with small groups of students on the computer.

Ms. Cameron gave two half-day workshops in the spring of 1983 for fifty-eight teachers from eight of the schools in her school board. She taught Part I of the Computers in the Classroom course during the summer of 1983.

During the second year of the study, she gave presentations to three groups of people including area principals, had two days off school to write Logo-curriculum material for her board, and received several visitors into her classroom. She successfully resisted many other demands on her time from her school board and individuals. She increased the amount of parent-volunteer help from one morning per week to three, in order have more time to monitor what was happening at the computer. She taught her class all subjects except physical education, health, and library. This gave her five planning periods each week.

SITES 6a AND 6b: ATHABASCA PUBLIC SCHOOL

The School:

Athabasca Public School is a modern, well equipped Kindergarten to Grade 8 school in a suburban middle class area. In the first year of the study, there were 675 students, a staff of 25 classroom teachers, and a specialist staff that included two half-time music teachers, two full-time French teachers, one full- and one half-time gym teacher, and a full-time special education teacher.

The school owned one computer, a VIC 20, purchased by the principal with school funds. Only three teachers (Grades 1, 3/4, and 5) other than Mrs. Cook, used this computer in their classroom on a regular basis. Interest in Mrs. Cook's class grew very slowly. In March, she was asked to do a Logo workshop for the school on a Professional Activity day. In June, her students taught Logo to the Kindergarten class over a two week period. The special education teacher was sufficiently interested that she applied to the school board for a computer and a Logo sofware package for her classroom. In September 1983, the school purchased a COMMODORE 64 which was rotated through the primary division.

During the second year of the study, the interest among teachers continued to grow. At the beginning of the year, seven staff members accepted Mrs. Cook's offer to give a few computer sessions during lunch hour. Teachers also began to visit the classroom to see what her students were doing. In November 1983, Mrs. Cook gave a workshop for the staff on the COMMODORE 64.

The principal was supportive of the use of computers in the classroom, however, he found little time to observe students in Mrs. Cook's class.

The Class - Site 6a:

This was a Grade 5 classroom of 27 students, 15 boys and 12 girls, from nine to eleven years in age. They were considered to be of average ability; however, one child was identified as hyperactive and another as having a specific learning disability. Twelve of the students had been taught by Mrs. Cook the previous year in Grade 4.

The physical arrangement of the classroom was very pleasant. It was furnished with colorful tables that were casually grouped. A comfortable meeting area with a rug, cushions, and a sofa was the focal point of the classroom. Students' art and writing were displayed everywhere and reading materials were abundant. The APPLE II+ computer and printer, both provided by this project, were on tables at the front of the room next to the teacher's desk. In January 1984, a second APPLE II+ was added to the classroom. This class was also given copies of LCSI Logo and the Bank Street Writer together with the manuals.

Sixteen students in this class had had some exposure to computers prior to the project. Four children had computers at home. Only one child had had any previous experience with the Logo language.

The Class - Site 6b:

This was a split Grade 5/6 classroom of 30 students, 18 boys and 12 girls. Ten of the students were in Grade 6 (four girls and six boys) and the rest were in Grade 5 (twelve boys and eight girls). The Grade 6 students had been with Mrs. Cook the two previous years. One of the Grade 5 students had a physical disability and from March to the end of the school year was assigned a teaching assistant. Two-thirds of the students in this class had used a computer the previous year and eight of them had computers at home.

The classroom arrangement was very similar to that of the previous year, except that there were four instead of two APPLE II+ computers and two printers, all provided by this project, on tables along the front of the classroom. A Koala Pad was added in April. Copies of Terrapin Logo and the Bank Street Writer were also given to the class. These students also used LCSI Sprite Logo for a month at the end of the year.

The Teacher - Site 6a and 6b:

Mrs. Cook is a very experienced teacher who has taught Grades 1 to 8. Her special areas of interest are humanistic education, creative language, and outdoor education. She describes herself as a promoter of the humanistic classroom. She uses Fader groupings and holds class meetings where students can discuss problems and make decisions about their classroom.

She has given many workshops for teachers on topics of humanistic education, psycholinguistic reading theory, team teaching, and outdoor education.

Mrs. Cook started using a Vic 20 in her classroom in the spring of 1982. After being introduced to Logo at the ECOO conference, she managed to get an APPLE II+ computer on loan from her board over the summer to explore the language. She completed the Computers in the Classroom Part I course in April 1983 and Part II in April 1984. She gave presentations at the ECOO in 1983 and 1984, and has given several workshops for her county. During the 1984 school year she had been a member of several computer-related committees and had written Logo-curriculum material for her Board.

SITES 8a AND 8b: VANIER PUBLIC SCHOOL

The School:

Vanier Public School was a regular Kindergarten to Grade 8 school located in a middle to upper middle class area. During the study, there were 375 students and 22 teachers at the school.

At the beginning of the study there was little interest in computers in the school even though the school had purchased an APPLE II+ computer. Little software and no disks were available for it.

During the 1982/83 school year, five teachers enrolled in a general computer course given by the local school board, but only three of them completed it. Out of 22 teachers on staff, only three showed any interest in the computer activity in the class that participated in this study. The school's APPLE II+ computer was available to the teachers for two-week periods but often it was not used. The only other teacher working in Logo was Ms. Issac, the teacher of the Grade 6 bilingual class. The special education teacher was given a COMMODORE 64 by the local school board to use in her classroom.

By the beginning of the 1983/84 school year, the school had two COMMODORE 64 computers and a printer for the APPLE II+. In addition, five teachers were using their own personal computers in their classrooms. These teachers were mainly using BASIC. During the year two more teachers added computers to their classrooms.

Interest in computers and Logo increased among the teachers during the second year of the study. For one month during the year, Mr. O'Sullivan and the Grade 5 teacher had an arrangement whereby the Grade 5 teacher taught Mr. O'Sullivan's Grade 8 English class while her class worked with Logo in Mr. O'Sullivan's room.

The Class - Site 8a:

There were 26 students in this combined grade 6/7 class, 11 boys and 15 girls, ranging in age from ten to twelve. Of the ten students in Grade 7, seven were considered to be above- and the other three of average ability. The Grade 6 class was considered to be of above-average ability.

This class had little exposure to computers before the beginning of the study. A TRS-80 computer was in the school for four weeks the previous year and was used by all classes. The school owned an APPLE II+ computer and Mr. O'Sullivan used it in his classroom for nine days in September prior to the arrival of the APPLE II+ computer and printer from this project. This class was also given copies of LCSI Logo and the Bank Street Writer. A second APPLE II+ computer was added in January and a COMMODORE 64 in April 1983.

The classroom was small but had a friendly atmosphere. At the beginning of the year, the students' desks were arranged in diagonal lines facing the teacher's desk at the front left corner of the room. The computer was on a table at the back of the room. In January, when the second computer was added, the teacher's desk was moved to the back of the room next to the two computers. On the wall behind the computers were several challenges posted by the teacher and the students.

The Class - Site 8b:

This was a class of 32 students, 15 girls and 17 boys. Sixteen of these students, ten girls and six boys, had been in Mr. O'Sullivan's class the previous year. They were considered an average class, however, the continuing group was a higher achieving group than the new group.

All of the new students had had some exposure to the school's computer during the previous year.

The classroom was again friendly but very small. It was furnished with large tables in horizontal rows facing the front blackboard. At the beginning of the year, two computers, an APPLE II+ and printer and an APPLE IIe, provided by this project, were at the front of the room next to the teacher's desk. Two more computers, an APPLE II+ and printer and an ATARI computer, also provided by this project, were at the back of the room behind a divider. Later in the year, the divider was removed and all four computers were placed at the back of the room. A COMMODORE 64 computer was added at the teacher's request in December 1983. Since the room had only two small windows, opening onto an enclosed courtyard, ventilation was poor and on a warm day it got very hot. The heat generated by the computers was considerable and added to the discomfort.

The Teacher - Site 8a and 8b:

Mr. O'Sullivan was an exchange teacher from another public school in the district and expected to be at Vanier School for at least two years. He was a very experienced teacher who had taught all grades from three through to adult education. Mr. O'Sullivan had given many workshops in a variety of subjects including special education, industrial arts, literacy, and adult education. He had also given computer awareness seminars.

Mr. O'Sullivan had a microcomputer in the classroom at his previous school for about six months. He first heard about Logo in the winter of 1981 and used it as an experiment for one period a day for one week towards the end of the school year. Prior to the beginning of this study, he had taken two computer courses: BASIC for Beginners at a local high school, and a Logo course at Queen's University. He completed the Computers in the Classroom Part I course in April 1983 and Part II in April 1984. He was familiar with a variety of computers: APPLE, COMMODORE PET, and TRS-80. He had given three in-service training sessions using the COMMODORE PET computer.

During the first year of the project, Mr. O'Sullivan gave up his free periods to teach Logo to other classes in the school, and gave up his recess and lunch hours to supervise the students who were working on the computers in his classroom. He also spent many hours supervising students from other classes working on his computers before and after school hours. In January, at the request of the parents, he started an after-school computer club to teach BASIC. In the spring, he was involved in organising a Computer Fair at a local shopping centre. Mr. O'Sullivan was also on many committees concerning computers and gave many workshops during the year.

During the second year of this project, there were even greater demands on Mr. O'Sullivan's computer expertise. As well as having a very heavy teaching load (he taught language arts, science, mathematics, and art to his own class, and language arts to the the other Grade 7 and the Grade 8 bilingual classes in the school), he served on several committees and was frequently called upon as a resource person by other teachers in the district and by parents in the community. He gave many workshops on the APPLE II+ and the COMMODORE 64 to other teachers and had frequent visitors to his classroom.

SITES 9a and 9b: BRANDON PUBLIC SCHOOL

The School:

Brandon Public School was a Kindergarten to Grade 8 school of approximately 300 students in a mixed socio-economic and a mixed suburban-rural area. It had a staff of eleven classroom teachers, a full-time French teacher, and a half-time music and library teacher.

The principal, Mr. Irwin, had actively encouraged the use of computers in the school and in the late fall of 1981 the school purchased an APPLE II+ computer. This computer was on a portable cart and could be signed out by teachers for one week at a time. It was used by every class in the school with drill and practice software during the year. Logo was purchased by the school in the spring of 1982 and during the two years of the project, several teachers became interested in using it.

Prior to the study, two teachers took a computer literacy course offered by their school board, and the whole staff had a day's workshop on computers and a software demonstration at a nearby high school. Mr. Vincent (who participated in the study), and a Grade 3/4 teacher took a Logo course that was offered by their school board.

During the two years of the project, Mr. Vincent was called upon to teach Logo to other teachers in the school and to give introductory Logo instructions to some of the classes.

The Class - Site 9a:

This was a Grade 7/8 consisting of 32 students, 15 in Grade 8 and 17 in Grade 7, from eleven to fourteen years of age. There were 17 girls and 15 boys. Mr. Vincent described his class as having an average distribution of ability. One boy had a specific learning disability and functioned well below grade level.

All but one child in this class had used a computer the previous year. They had used drill and practice software, and were introduced to Logo in the late spring.

At the beginning of the year, the classroom was fairly traditional in physical organization with desks arranged in double rows, but later the desks were rearranged to form a double horseshoe pattern with the students facing each other. The one computer in the classroom, an APPLE II+, and a printer, supplied by the project, were on a desk against the back wall next to the teacher's desk. It was a very pleasant room with students' art, writing, and social studies displays decorating the walls. The class schedule was organized around a rotary six-day cycle, and all afternoons except for three history periods were spent outside the classroom.

The computer, printer, and copies of Terrapin Logo and the Bank Street Writer were provided by the study.

The Class - Site 9b:

There were 33 students in this Grade 8 class, 16 boys and 17 girls. Fifteen of the students - 7 boys and 8 girls - were with Mr. Vincent the previous year. All of the students had used a computer before and eight had computers at home.

At the beginning of the year, the desks were arranged in two concentric rectangles with the students facing each other, but later were rearranged to form traditional rows facing the blackboard. There were two computers, an APPLE II+ and an APPLE IIe, and one printer in the classroom; all provided by the project. These were placed at the back of the classroom next to the teacher's desk and were separated by a bookshelf.

The Teacher - Site 9a and 9b:

Mr. Vincent was a very experienced intermediate-level teacher whose special areas of interest were science, mathematics, and social studies. His teaching responsibilities in the first year of the study included core subjects for his Grade 7 and 8 students as well as geography for the other Grade 7 classes in the school.

Prior to the project, Mr. Vincent had taken computer courses at Queen's University in FORTRAN and Assembly Language. He had also taken courses in BASIC and Logo given by his school board. He used drill and practice software, games, and Logo with a class prior to the study.

He had not taken any computer-related courses during the two years of the study but attended a workshop on advanced Logo graphics and list operations. During the two years of the project, Mr. Vincent, in addition to giving some instructions on Logo to teachers and students in the school, spoke to the school's parent advisory group and served on computer-related committees at his school board.

SPECIAL EDUCATION CLASSES

SITE 12a: RIVERSIDE PUBLIC SCHOOL

The School:

Riverside Public School was located in one of the poorer parts of the city. It was a regular Kindergarten to Grade 8 school with 187 children.

The principal of the school, Mr. Greenwood, was very interested in computers and often visited the classroom that was part of the study to see what the students were doing. The computer supplied by the project was the only computer in the school and it attracted other students and teachers to the classroom. Six Grade 7 students, who had had some previous Logo experience, came into this classroom during recess and lunchtime to work on the computer. This was the first time that any students from other classes had come to the room even though the teacher had invited them in the past to listen to his sound system. This room was unofficially "off limits" to the rest of the school until the arrival of the computer.

The Class:

This was a Junior-Intermediate adjustment class of five boys, ranging in age from nine to fourteen years. Only one boy lived within walking distance of the school, the other four were brought by bus or taxi from other schools in the district. The students had been in this class for varying lengths of time. Chris, the youngest boy, had been in a special education class since he started school; Frank, who was 14, had been in this class for four years; the others only for a few months. There was a very wide ability range: Chris could not read or write, whereas Frank had just started to go to the regular Grade 7 class for science.

Only one of the five children in this class had seen a computer before the project began. Steve had a "Big Brother" who studied computer science at Queen's University and who had taken Steve to the university's Computing Centre on occasion. None of the boys had heard of Logo prior to the study.

The classroom was large and bright and decorated with the students' work. The computer was at the back of the room next to the reading and listening area.

All five students in this class were from single parent families, with very poor home backgrounds. A special breakfast program was provided at the school for them.

The Teacher:

Mr. Veley had taught Grades 5 and 6 and had been a special education resource person. He had given workshops in drama, theatre arts, music, and on deafness. His special interests were music, both vocal and instrumental, and theatre arts. His main hobby is working in the theatre.

Mr. Veley had taken a computer course on FORTRAN while still in high school, but had had no other computer training or experience. He considered himself as being "hopeless" with technology. He had never used a computer in his classroom before this project, and initially, was very hesitant to take it into the classroom. He was afraid of the technology, and considered computers to be very impersonal. He was also concerned about the possibility that the boys might become frustrated and damage the computer.

Mr. Veley had a great attachment to his "boys". At the beginning of the school year, until it was taken over by the P.T.A., he made breakfast for the boys each day. He frequently gave them money to buy lunch or took someone out to dinner.

SITE 13a: GRAHAM PUBLIC SCHOOL

The School:

Graham Public School is located in a mixed socio-economic area in the city. It is a typical Kindergarten to Grade 8 school with 350 children.

In 1983, the school owned one APPLE II+ computer which was rotated among the classes. Two teachers, the Grade 3 and the special education teacher, took a course on Logo offered by their local school board. During the study, several teachers and students from other classes came to this room during recess and lunchtime to learn about computers. Children from Grade 1 and Grade 2 came in pairs to work at the computers, with the learning disabled students as their teachers. The local school board had a computer resource centre and when classes from this school visited the centre, the students from the learning-disabled class often were asked to go along and act as teachers and supervisors.

The Class:

This was a Junior-Intermediate Specific Learning Disability class of seven students, all between eleven and thirteen years of age. There were six boys and one girl. They were only involved in the study for four months.

Only one of the students had never used a computer before. Five students had previously used computers at school and one at a friend's house. Two students had some experience working in Logo.

The classroom was large and bright. There were two large clusters of tables, one for group work and one for specific activities, as well as individual desks for working alone. The APPLE II+ computer and printer provided by the study, formed one of the activity centres in the classroom.

The Teacher:

Ms. Tinsdale had taught junior Kindergarten and had been a special education resource person. She had also given workshops in special education. Her main interests were art and language arts.

Ms. Tinsdale felt very uneasy about mathematics and working with computers. In the fall of 1982, in anticipation of participating in our study, she attended a course on Logo offered by her school board. In early 1983, while she was involved in our study, she repeated the course, in order to reinforce her own learning, as well as to get help with specific questions that were raised by her own students.

C. Some Samples of Guidelines and Questionnaires Used for Collecting and Processing Data

ITEM A

COMPUTERS IN EDUCATION PROJECT

GUIDELINES FOR SITE DESCRIPTIONS

1. TEACHERS:

   a. teaching style
   b. specialty and interests
   c. teaching background
   d. experience with computers
   e. experience with LOGO

2. CHILDREN:

   a. experience with computers
   b. experience with LOGO

3. CLASS:
   a. grade
   b. number of children
   c. boy-girl composition
   d. ability range
   e. age range
   f. location of computer

4. SCHOOL:

   a. attitudes of principal and other teachers in school to computers
   b. no. of teachers in school who have attended computer workshops
   c. no. of teachers who have worked with computers
   d. no. of teachers who have worked with LOGO
   e. the grade level of (c&d) above
   f. other activities in school that involve computers
   g. physical arrangement of computer(s)

5. COUNTY:

   a. general computer activity within the county
   b. no. of machines in county
   c. how these machines are being used
   d. where these machines are being used
   e. nature of in-service sessions within school board
   f. consultants or other personnel involved with computers
   g. type of software and general use of computers

October 1, 1982

ITEM B

COMPUTERS IN EDUCATION PROJECT

GUIDELINES FOR RECORDING AN OVERVIEW OF COMPUTER ACTIVITIES

Name: ____________________

School: ____________________

Grade: ____________________

Observation Period: __________ to __________

NOTE: In order to help us reach the objectives of the study, we ask you to reflect upon these questions. Please support your observations with examples or anectodes whenever possible.

The questions in bold print are those that have to be addressed in the final report to the Ministry of Education. The questions and comments in regular print attempt to offer more specific guidelines for each major heading.

Please base your comments on what you have actually observed over the length of the study. If you feel that you cannot comment on a particular question, please indicate so.

FACULTY OF EDUCATION
QEEN'S UNIVERSITY
KINGSTON, ONTARIO

SUMMARY

(1) **What effects does a creative software program such as LOGO have upon:** (Pink sheets)

- (a) Self esteem: (p.3)
- (b) Peer relationships: (p.3)
- (c) The teacher-student interaction: (p.4)
- (d) The classroom environment: (p.4)
  - (i) physical organization:
  - (ii) time tabling, activities:

(2) **What areas of the school program are best supported by the creative use of the computer in the classroom? For example, areas such as:** (Mustard sheets)

- (a) Mathematics Skills: (p.5,6)
- (b) Artistic design: (p.7,8)
- (c) Logic: (p.9,10)
- (d) Problem solving: (p.11,12)
- (e) Reading and writing: (p.13,14)
- (f) Other: (p.15,16)

(2.1) Is there a concept that a teacher can explain better using a computer (LOGO)?

(2.2) Can students explore a concept more deeply with computers than without it?

(2.3) Is there a transfer effect from computer activities or thinking to other areas of the curriculum?

(2.4) Other.

(3) **What specific skills, identified in the Formative Years, are more easily mastered by using a creative software program such as LOGO?**

(4) **What changes, if any, are suggested in curriculum policy, given widespread use of creative computing software?** (Blue Sheets)

(4.1) In aims and objectives? (p.17)

(4.2) In the sequence of presentation? (p.17)

(4.3) In the medium of presentation? (p.18)

(4.4) Are there surprises in cognitive actvity in children ? (For example, are children grasping ideas or concepts at an earlier stage with this medium? If yes, how much earlier?) (p.18)

(5) How does a creative software program such as LOGO enhance the teaching/learning environment to meet the objectives outlined in the Formative Years ? (Blue sheets)

(5.1) Does the computer (LOGO) enhance motivation? (p.19)

(5.2) Does the computer (LOGO) accommodate individual differences in ability? (p.19)

(5.3) Does the computer (LOGO) accommodate different learning styles? (p.20)

(5.4) Does the computer (LOGO) facilitate creative thinking? (p.20)

(5.5) Does the computer (LOGO) challenge potential? (p.21)

(5.6) Does the computer (LOGO) bring out abilities that have not been recognized in the traditional school setting. (p.21)

(6) What effects does the computer have on the rest of the school? (Yellow sheets)

(a) On teachers: (p.22)
(b) On students: (p.22)
(c) On the principal: (p.23)
(d) On the administration: (p.23)
(e) On the interaction of any of the above: (p.23)

(7) What effects, if any, might there be on present programs and practices in teacher education? (Green sheets)

(7.1) On the role of teacher: (p.24)

(7.2) On the need for support groups in coping with innovation and change: (p.24)

(7.3) On the structure of teacher training: (p.25)

(7.4) On continuing education, teacher development, in-service: (p.25)

(7.5) On incentives to change or accept the computer technology: (p.26)

(7.6) On the personal costs and benefits involved: (p.26)

(8.) Other observations? (White sheets: p.27)

(For example: Are there any differences between boys and girls in their use or attitudes of computers?)

DOCUMENT B

COMPUTERS IN EDUCATION PROJECT

SUMMARY OF RESPONSES TO PROJECT QUESTIONS ("ITEM B")
AND DATA FROM "DOCUMENT C"

(THE FRAMEWORK OF THIS DOCUMENT CONSISTS OF QUESTIONS 2 AND 3 OF "DOCUMENT C" AND ALL OF THE QUESTIONS OF "ITEM B". ALL INFORMATION CONTAINED IN "DOCUMENT C" WAS REORGANIZED ACCORDING TO THIS FRAMEWORK AND COMBINED WITH THE INFORMATION CONTAINED IN "ITEMS B" - ALL IN CHRONOLOGICAL ORDER.)

Name: ______________________________

School: ______________________________

Grade: ______________________________

Observation Period: September 20, 1982 to ______________

FACULTY OF EDUCATION
QEEN'S UNIVERSITY
KINGSTON; ONTARIO
December 1982

SUMMARY

(0) General Remarks About the Day/Week (or Visit):

(1) Describe how you schedule the use of your computer and how you arrived at your schedule or what factors influenced your decision:

(2) Describe the LOGO activities that you presented to your class or to individuals (please indicate which) this week:

(3) Describe your students' computer activities that they engaged in this week:

(4) Describe or state any positive results that emerged from these activities (give specific examples or anectodes):

(5) Describe or state any problems that you or your students encountered and indicate how you resolved them (if you were able to do so):

(6) Describe any activities, other than on the computer, that were generated by activities, ideas or concepts on the computer:

(7) Describe or state the factors which influence the way you use your computer and/or the activities that you engage in:

(8) Describe any difficulties that you have with your hardware or with the support documents:

(9) Describe the kind of support that you would need in order to utilize the computer more effectively:

(10) Describe the activities, interests or concerns in the rest of the school that are due to the computer activities in your classroom:

(11) Describe the kinds of LOGO (or other) activities which you engaged in yourself in preperation for classroom use:

(12) Remarks or concerns with respect to the physical aspect of the computer arrangement and other hardware items:

(13) Comments, problems, and/or frustrations with respect to the nature of the project:

(14) Miscellaneous:

(15) General Classroom Atmosphere:

(16) Describe the methodolgical problems that you encounter in collecting the desired information and making the necessary observations:

ITEM C

COMPUTERS IN EDUCATION PROJECT

SITE OVERSATIONS BY TEACHERS OR RESEARCHERS

for the period of

__________ to __________

SCHOOL: __________

TEACHER: __________

GRADE: __________

NOTE: Please record your activities and observations on a regular basis on these sheets.

FACULTY OF EDUCATION
QUEEN'S UNIVERSITY
KINGSTON, ONTARIO

DOCUMENT C

COMPUTERS IN EDUCATION PROJECT

SUMMARY RECORD OF OBSERVATIONS BASED ON ITEM C

(This document is a compilation of all entries in ITEM C arranged chronologically under each of the 16-question headings.)

at

NAME OF SITE

For the period from September 20, 1982 to ______________

FACULTY OF EDUCATION
QUEEN'S UNIVERSITY
KINGSTON, ONTARIO

ITEM D.1

ACTIVITY SHEET FOR STUDENTS AT SITE 10a (COMPUTER LABORATORY)

Name: Date:

My partner before lunch was:

My partner after lundh was:

Before lunch I worked on the following procedures or pictures:

After lunch I worked on the following procedures or pictures:

What did you like or dislike about working by yourself today:

What did you like or dislike about working with your partner today:

Of the things you did today, what did you like best:

Why:

Of the things you did today, what did you like the least:

Why:

What did you learn today:

What else would you like to learn:

ITEM D.2

ACTIVITY SHEET FOR STUDENTS IN THE JUNIOR AND INTERMEDIATE CLASSES (1983/84)

SCHOOL: B_____ C_____ W_____ GRADE:______ DATE:__________

MY NAME:______________________________ PARTNER'S NAME:______________

COMPUTERS-IN EDUCATION PROJECT-1983/84

1. I worked with the following software:

(a)_____Logo: Turtle Geometry
(b)_____Logo: Text
(c)_____Logo: Music
(d)_____Bank Street Wr.
(e)_____other:
(state what)____________
____

2. I worked approximately:

(a)_____10 - 19 minutes
(b)_____20 - 29 minutes
(c)_____30 - 39 minutes
(d)_____40 - 49 minutes
(e)_____50 - 60 minutes

3. I worked on: _____same thing as before _____something new

(a)_____assignments or teacher challenge
(b)_____cards, handout, manual or book
(c)_____my computer partner's idea
(d)_____my own idea

If your own idea, what:______________________________
____

4. Who decided what you did on the computer?

(a)_____I did
(b)_____my partner did
(c)_____my partner and I decided together
(d)_____the teacher did
(e)_____other:______________________________

5. Did you need any help while working on the computer?

___Yes___No

If yes, where or to whom did you go for help?

(a)______gave up
(b)______my computer partner
(c)______my assigned class computer consultant
(d)______my classroom teacher
(e)______book,magazine, manual: name____________________________ page_______
(f)______another classmate: who__________________________________
(g)______another teacher: who __________________________________
(h)______other____

6. If you needed help, briefly state with what:____________________

____

____

____

7. Did the activity on the computer give you ideas for further work or raise some questions for you?

______Yes ______No

briefly explain:____

____

____

8. Did you like what you were doing today? _____Yes _____No

Why?____

____

____

____

9. What did you like or dislike about working with your partner today?

____

____

____

10. Comments and/or questions:

____

____

____

ITEM E.1

POST QUESTIONNAIRE FOR PRIMARY LEVEL STUDENTS - MAY 1983

QUEEN'S UNIVERSITY

COMPUTERS IN EDUCATION PROJECT

NAME: ______________________________ AGE: ________ GRADE: __________

SCHOOL: ____

PART I: (Note: The researcher is to read each question and the categories for responses to the student and record the answer on this sheet.)

1. Did you enjoy having a computer in your classroom?

Yes_____No_____

2. Would you miss not having a computer in your class next year?

Yes_____No_____ Maybe_____I don't know_____

3. Are there things you didn't like about having a computer in your class?

____

____

4. Do you feel that you got enough time on the computer? Yes_____No_____

5. Of all the things you have done on the computer what did you like:

Best ____

Least ____

6. If you could do whatever you wanted to do on the computer, what would you choose?_

____

7. What have you learned from working with the computer?____________

____

____

8. Do you find that working on the computer has helped you learn other things easier?

Yes_____No_____I don't know_____

If yes, explain: ____

____

9. Do you think computers are for:

Boys_____Girls_____Either_____Grown-ups_____Everybody_____

10. What kinds of things do you like to do when you are at school?____________

____

PART II: PRIMARY POST LOGO QUIZ - NON-COMPUTER PORTION (MAY 1983)

NOTE: Instructions to be read by the researcher to the student. The researcher is to make sure that the student understands the questions and, if necessary, clarify ambiguities. The student should do the writing and sketching on the sheets provided. If the student appears to be under too much stress or does not wish to continue answering questions, stop immediately.

(EACH SET OF QUESTIONS WAS PRESENTED ON A SEPARATE SHEET OF PAPER.)

ASK.1: CAN YOU WRITE DOWN SOME TURTLE COMMANDS?

ASK.2: CAN YOU SKETCH HOW THE TURTLE WOULD DRAW THESE COMMANDS (of ASK.1)?

ASK.3: CAN YOU FILL IN THE BLANKS IN

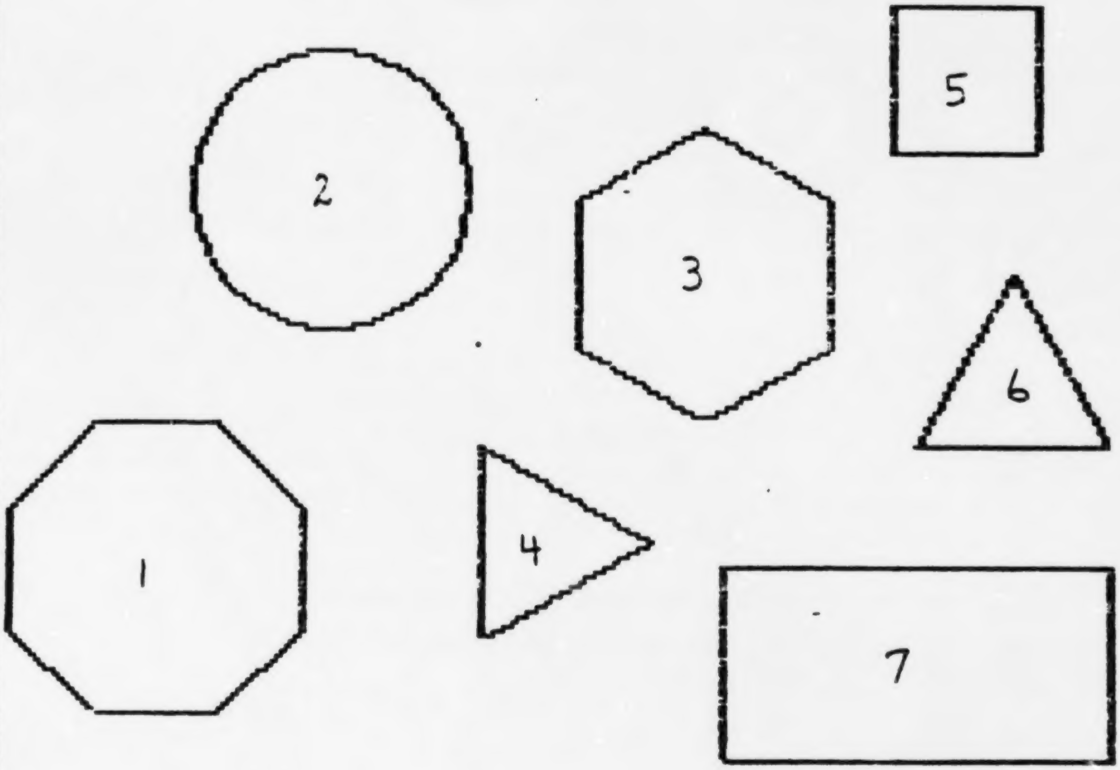
```
REPEAT ..... [FD.... LT.....]
```

AND SKETCH WHAT THIS WOULD DRAW?

ASK.4: CAN YOU WRITE A PROCEDURE?

ASK.5: DO YOU KNOW WHAT THIS PROCEDURE (of ASK.4) WILL DRAW?

ASK.6: DO YOU KNOW WHAT THE FOLLOWING SHAPES ARE CALLED?



1 ______________________________

2 ______________________________

3 ______________________________

4 ______________________________

5 ______________________________

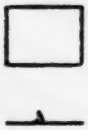
6 ______________________________

7 ______________________________

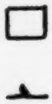
PART III: PRIMARY POST LOGO QUIZ - COMPUTER PORTION (MAY 1983)

NOTE: This portion of the quiz is to be loaded from the pre-programmed disk into the computer before the students arrive. The researcher is to type ASK._ whereupon the drawing and instructions appear on the computer screen. Instructions are also to be read aloud by the researcher. The researcher is to make sure that the student understands each question and, if necessary, clarify ambiguities. The student types his/her responses on the keyboard and the researcher records these responses on the appropriately prepared sheets of paper. If the student appears to be under too much stress or does not wish to continue answering questions, stop immediately.

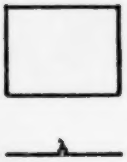
ASK.7: TYPE 40. HOW FAR IS IT TO THE TOP OF THIS SQUARE?



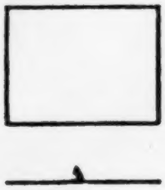
ASK.8: TYPE 40. HOW FAR IS IT TO THE TOP OF THIS SQUARE?



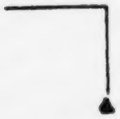
ASK.9: a. HOW FAR IS IT TO THE BOTTOM OF THE SQUARE?
b. HOW FAR IS IT TO THE TOP OF THIS SQUARE?



ASK.9: a. HOW FAR IS IT TO THE BOTTOM OF THE SQUARE?
b. HOW FAR IS IT TO THE TOP OF THE SQUARE?

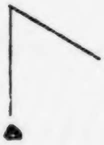


ASK.10: a. TYPE FD 80. CAN YOU TRACE OVER THIS BLUE LINE?

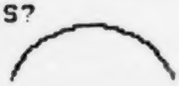


b. CAN YOU MAKE A SQUARE OUT OF IT?

ASK.11: TYPE FD 80. CAN YOU TRACE OVER THIS BLUE LINE?



ASK.12: CAN YOU MAKE A SHAPE LIKE THIS?



ITEM E.2

QUEEN'S UNIVERSITY

COMPUTERS-IN EDUCATION PROJECT

JUNIOR/INTERMEDIATE POST-QUESTIONNAIRE - APRIL 1984

NAME: ______________________________ AGE: ________ GRADE: ____________

SCHOOL: ____

PART I

DIRECTIONS: Indicate how much you agree or disagree with each of the following statements by putting a check mark in front of the appropriate answer.

1. I would like to learn more about computers:

____Yes, very much ____No ____I don't know

____Yes ____Definitely not

2. (Ignore)

3. I feel confident about my ability to use computers:

____Yes, very much ____No ____I don't know

____Yes ____Definitely not

4. (Ignore)

5. Every student should know something about computers:

____Yes, very much ____No ____I don't know

____Yes ____Definitely not

6. The use of computers in the classroom results in less personal treatment of students by the teacher:

____Yes, very much ____No ____I don't know

____Yes ____Definitely not

Briefly explain your answer: ______________________________

____

____

____

____

PART II

We would like you to give us information about yourself by answering the questions below. If you do not want to answer a question, you may leave the space for that question blank.

7. (Ignore)

8. (Ignore)

9. Do you have a computer in your home?

____Yes ____No

If yes: what kind? ________________________________

How long have you had it? ____________________

About how many hours a week do you work/play on the computer at home?

___less than 2 hrs.
___2-15 hrs.
___15-30 hrs.
___more than 30 hrs.

What kinds of things do you do on the computer at home?

____

How do you spend your time on the computer at home?

___alone ___with a friend ___both

10. (Ignore)

11. Have your parents encouraged you to learn about computers?

____ ____No

12. Have your friends encouraged you to learn about computers?

____Yes ____No

13. Have you read articles about computers?

____Yes ____No

If yes, where? ___magazines ___books ___newspapers

14. Where have you learned most about computers? (Put a 1 in front of the one from which you learned the most, 2 in front of the next most, then 3, 4, 5, 6, and 7 in front of the one from which you learned the least.)

___ from movies and television
___ from books, manuals, magazines and newspapers
___ from my parents
___ from my friends outside the class
___ from my teachers at school
___ from my classmates at school
___ from computer courses outside school
___ other ______________________

PART III

15. From among the list below choose the THREE subjects that you enjoy the most. Put a 1 for most, 2 for next most and 3 for the next one.

___English
___French
___Art
___Science
___Gym
___Shop or Family Studies
___Mathematics
___Social Studies
___Music
___Computers
___Other
what?__________

16. (Ignore)

17. (Ignore)

18. My grades this year are:

___mostly A's
___mostly B's
___mostly C's
___mostly D's
___an even mix between ___ and ___
(please fill in the spaces with the appropriate letters)

19. Regardless of your grades, how bright do you think you are in comparison to the other students in your class? (Check off only one answer.)

___ well above average
___ slightly above average
___ average
___ slightly below average
___ well below average

QUEEN'S UNIVERSITY

COMPUTERS-IN EDUCATION PROJECT

JUNIOR/INTERMEDIATE POST-QUESTIONNAIRE - APRIL 1984

NAME: ______________________________ AGE: ________ GRADE: ____________

SCHOOL: ____

PART IV

DIRECTIONS: Please check the appropriate answers and give a short explanation of your answer where asked for.

20. (Ignore)

21. Do you think computers will affect the way teachers will teach in the future?

_____Yes _____No

Explain: ____

____

____

____

22. Do you think the way you learn with the computer is different from the way you learn without a computer?

_____Yes _____No

Explain: ____

____

____

____

PART V

23. Has working with the computer affected how you think about yourself?

____I feel much more confident about my abilities in general
____I feel more confident about my abilities in general
____No change
____I feel less confident about my abilities in general
____I feel much less confident about my abilities in general

24. Do you enjoy working with a computer-partner?

_____Yes _____No

Briefly explain your answer ____________________________________

____

25. Do you enjoy having a computer in your classroom?

_____Yes _____No

26. Are there things you didn't like about having a computer in your class?

____

____

27. Of all the things you have done on the computer what did you like:

Best ____

Least ____

28. Do you find that working on the computer has helped you learn other things more easily?

_____Yes _____No

Briefly explain: ____

____

____

29. If you could do whatever you wanted to do on the computer, what would you choose to do?

____

30. What have you learned from working with the computer? ____________

____

31. What have you learned from working with Logo? ________________

____

____

32. Did you change computer partners during the year?

_____Yes _____No If yes, how many times?_____

If yes, briefly explain why you changed ____________________

____

____

33. Would you like to have worked on the computer by yourself?

_____Yes _____No

Briefly explain your answer ______________________________

____

QUEEN'S UNIVERSITY

COMPUTERS-IN EDUCATION PROJECT

JUNIOR/INTERMEDIATE POST-QUESTIONNAIRE - APRIL 1984

NAME: ______________________________ AGE: ________ GRADE: ________

SCHOOL: ____

PART VI

DIRECTIONS: Please put a check mark in front of the answer that you feel best answers the following questions.

Compared to writing with paper and pencil:

34. Is writing with a wordprocessor

_____harder _____easier _____the same

Explain ____

____

35. Are the stories that you write with a wordprocessor

_____longer _____shorter _____the same

36. Do you worry about making mistakes?

_____more _____less _____the same

37. Do you make corrections or changes

_____more often _____less often _____the same

38. Do you let others read your stories

_____more often _____less often _____the same

39. Do you prefer to write your stories

_____alone _____with your partner _____not at all

QUEEN'S UNIVERSITY
COMPUTERS IN EDUCATION PROJECT

NAME: ______________________ AGE: ____ GRADE: ______________

SCHOOL: ____

____

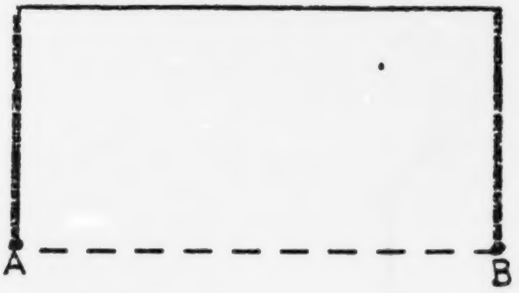
LOGO QUESTIONS - GRADES 3, 5, 6, 7 and 8

APRIL 1984

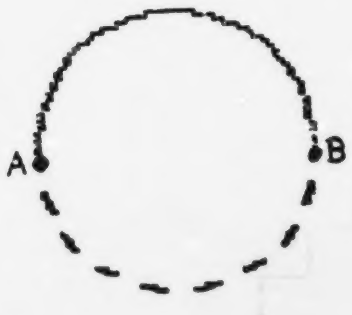
EXERCISE 1:

The turtle starts at position A (HOME), follows the given instructions and ends up at point B (see sketch). The turtle wants to get back to point A along the dotted line. Write down the necessary instructions.

(a)
```
FD 50
RT 90
FD 100
RT 90
FD 50
```



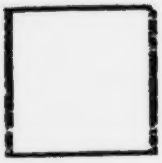
(b) `REPEAT 18 [FD 5 RT 10]`



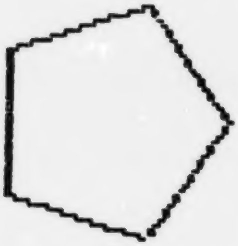
EXERCISE 2:

Write a procedure - using REPEAT statements if possible - for the following shapes.

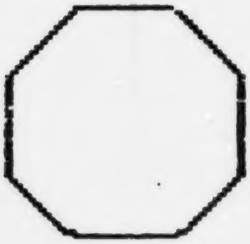
(a) SQUARE



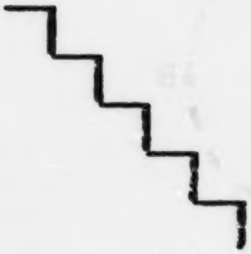
(b) PENTAGON



(c) OCTOGON



(d) STAIRCASE



EXERCISE 3:

Start at the HOME position. Sketch the shape the turtle would make if it followed the instructions below. Improve or correct the instructions wherever possible.

```
(a)  LT 30
    FD 80
    LT 120
    FD 80
    LT 120
    FD 80
```

```
(b) REPEAT 5 [FD 40 RT 90 FD 60 RT 90]
```

```
(c) REPEAT 100 [FD 10 RT 5]
```

```
(d)  TO HILLTOP :SIDE
     REPEAT 4 [FD :SIDE RT 90]
     HILLTOP :SIDE - 5
     END
```

Start with HILLTOP 20 and stop at HILLTOP 0

EXERCISE 4:

Write a procedure, using variables, so that you can use this procedure to draw the following shapes in different sizes:

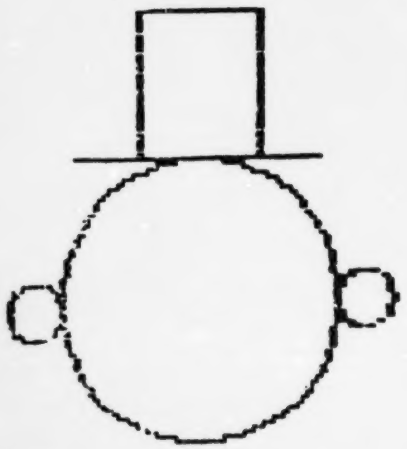
(a) a square:

(b) a rectangle:

(c) a star:

EXERCISE 5:

Write a procedure, using sub-procedures if you can, for the following shape:



EXERCISE 6:

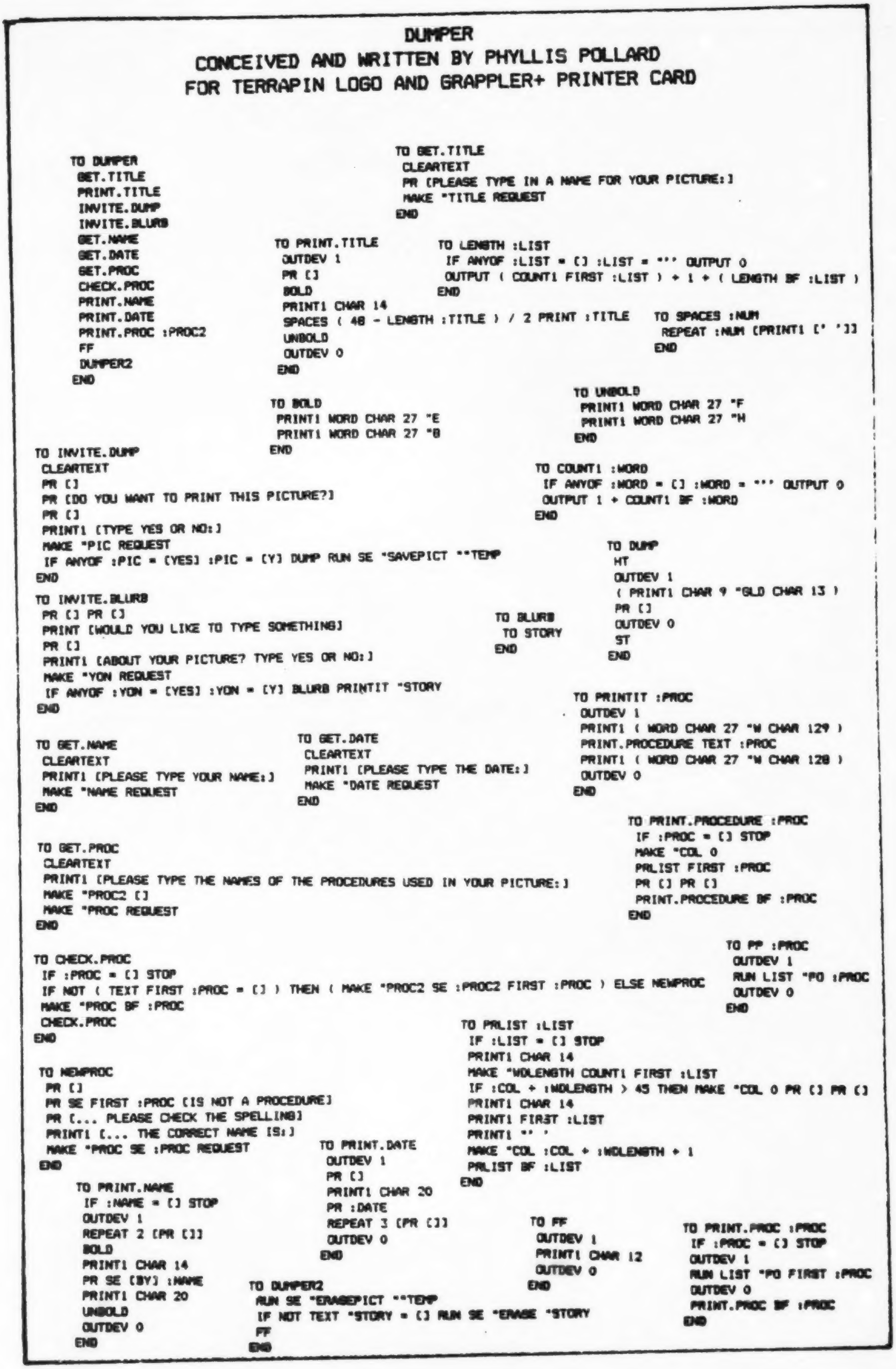
If the procedure to WIBBLE is defined as:

```
TO WIBBLE :N :L :A
 REPEAT :N [FD :L RT :A]
 END
```

(a) Sketch what the turtle will draw for WIBBLE 6 50 60

(b) Give the values of :N :L :A for WIBBLE to create a square.

D. Procedures Written Specifically for this Research



DUMPER
CONCEIVED AND WRITTEN BY PHYLLIS POLLARD
FOR TERRAPIN LOGO AND GRAPPLER+ PRINTER CARD

```
TO GET.TITLE
 CLEARTEXT
 PR [PLEASE TYPE IN A NAME FOR YOUR PICTURE:]
 MAKE "TITLE REQUEST
END
```

```
TO DUMPER
 GET.TITLE
 PRINT.TITLE
 INVITE.DUMP
 INVITE.BLURB
 GET.NAME
 GET.DATE
 GET.PROC
 CHECK.PROC
 PRINT.NAME
 PRINT.DATE
 PRINT.PROC :PROC2
 FF
 DUMPER2
END
```

```
TO PRINT.TITLE
 OUTDEV 1
 PR []
 BOLD
 PRINT1 CHAR 14
 SPACES ( 48 - LENGTH :TITLE ) / 2 PRINT :TITLE
 UNBOLD
 OUTDEV 0
END
```

```
TO LENGTH :LIST
 IF ANYOF :LIST = [] :LIST = "'' OUTPUT 0
 OUTPUT ( COUNT1 FIRST :LIST ) + 1 + ( LENGTH BF :LIST )
END
```

```
TO SPACES :NUM
 REPEAT :NUM [PRINT1 [' ']]
END
```

```
TO UNBOLD
 PRINT1 WORD CHAR 27 "F
 PRINT1 WORD CHAR 27 "H
END
```

```
TO BOLD
 PRINT1 WORD CHAR 27 "E
 PRINT1 WORD CHAR 27 "G
END
```

```
TO INVITE.DUMP
 CLEARTEXT
 PR []
 PR [DO YOU WANT TO PRINT THIS PICTURE?]
 PR []
 PRINT1 [TYPE YES OR NO:]
 MAKE "PIC REQUEST
 IF ANYOF :PIC = [YES] :PIC = [Y] DUMP RUN SE "SAVEPICT ""TEMP
END
```

```
TO COUNT1 :WORD
 IF ANYOF :WORD = [] :WORD = "'' OUTPUT 0
 OUTPUT 1 + COUNT1 BF :WORD
END
```

```
TO DUMP
 HT
 OUTDEV 1
 ( PRINT1 CHAR 9 "GLD CHAR 13 )
 PR []
 OUTDEV 0
 ST
END
```

```
TO INVITE.BLURB
 PR [] PR []
 PRINT [WOULD YOU LIKE TO TYPE SOMETHING]
 PR []
 PRINT1 [ABOUT YOUR PICTURE? TYPE YES OR NO:]
 MAKE "YON REQUEST
 IF ANYOF :YON = [YES] :YON = [Y] BLURB PRINTIT "STORY
END
```

```
TO BLURB
 TO STORY
END
```

```
TO PRINTIT :PROC
 OUTDEV 1
 PRINT1 ( WORD CHAR 27 "W CHAR 129 )
 PRINT.PROCEDURE TEXT :PROC
 PRINT1 ( WORD CHAR 27 "W CHAR 128 )
 OUTDEV 0
END
```

```
TO GET.NAME
 CLEARTEXT
 PRINT1 [PLEASE TYPE YOUR NAME:]
 MAKE "NAME REQUEST
END
```

```
TO GET.DATE
 CLEARTEXT
 PRINT1 [PLEASE TYPE THE DATE:]
 MAKE "DATE REQUEST
END
```

```
TO PRINT.PROCEDURE :PROC
 IF :PROC = [] STOP
 MAKE "COL 0
 PRLIST FIRST :PROC
 PR [] PR []
 PRINT.PROCEDURE BF :PROC
END
```

```
TO GET.PROC
 CLEARTEXT
 PRINT1 [PLEASE TYPE THE NAMES OF THE PROCEDURES USED IN YOUR PICTURE:]
 MAKE "PROC2 []
 MAKE "PROC REQUEST
END
```

```
TO PP :PROC
 OUTDEV 1
 RUN LIST "PO :PROC
 OUTDEV 0
END
```

```
TO CHECK.PROC
 IF :PROC = [] STOP
 IF NOT ( TEXT FIRST :PROC = [] ) THEN ( MAKE "PROC2 SE :PROC2 FIRST :PROC ) ELSE NEWPROC
 MAKE "PROC BF :PROC
 CHECK.PROC
END
```

```
TO PRLIST :LIST
 IF :LIST = [] STOP
 PRINT1 CHAR 14
 MAKE "WDLENGTH COUNT1 FIRST :LIST
 IF :COL + :WDLENGTH > 45 THEN MAKE "COL 0 PR [] PR []
 PRINT1 CHAR 14
 PRINT1 FIRST :LIST
 PRINT1 "' '
 MAKE "COL :COL + :WDLENGTH + 1
 PRLIST BF :LIST
END
```

```
TO NEWPROC
 PR []
 PR SE FIRST :PROC [IS NOT A PROCEDURE]
 PR [... PLEASE CHECK THE SPELLING]
 PRINT1 [... THE CORRECT NAME IS:]
 MAKE "PROC SE :PROC REQUEST
END
```

```
TO PRINT.DATE
 OUTDEV 1
 PR []
 PRINT1 CHAR 20
 PR :DATE
 REPEAT 3 [PR []]
 OUTDEV 0
END
```

```
TO PRINT.NAME
 IF :NAME = [] STOP
 OUTDEV 1
 REPEAT 2 [PR []]
 BOLD
 PRINT1 CHAR 14
 PR SE [BY] :NAME
 PRINT1 CHAR 20
 UNBOLD
 OUTDEV 0
END
```

```
TO FF
 OUTDEV 1
 PRINT1 CHAR 12
 OUTDEV 0
END
```

```
TO PRINT.PROC :PROC
 IF :PROC = [] STOP
 OUTDEV 1
 RUN LIST "PO FIRST :PROC
 OUTDEV 0
 PRINT.PROC BF :PROC
END
```

```
TO DUMPER2
 RUN SE "ERASEPICT ""TEMP
 IF NOT TEXT "STORY = [] RUN SE "ERASE "STORY
 FF
END
```

PRINTIT

```
TO PRINTIT :PRO
 OUTDEV 1
 PRP TEXT :PRO
 OUTDEV 0
END

TO PRP :PRO
 IF :PRO = [] STOP
 PRINT1 CHAR 14
 PRINT FIRST :PRO
 PR []
 PRP BUTFIRST :PRO
END
```

THIS PROGRAM WAS WRITTEN BY TOM BOYLE

Selected References

Selected References

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Bitter, Gary. "The Road to Computer Literacy: Part II, Objectives and Activities for Grades K-3". Electronic Learning, October 1982, pp. 34-37, 85-86. Logo by behavioural objectives "Grade One... Teach the students the commands Penup, Penerase, and Pendown... Reward students for good work by giving them blocks of "Doodle Time". (p.36).

Block, Jeanne. "The Pinks and the Blues". VISTA Television Series, March 1981.

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Classroom Computer News 3(5)(April 1983). A special issue on Logo with major articles by Ricky Carter, Dan Watt, Tom Lough, and Steve Tipps. In addition, there are a number of shorter articles and reviews. Highly recommended. "Already, Logo curriculum guides come replete with behavioral objectives, Logo work books and Logo multiple choice tests. Nothing could be more antithetical to the philosophy underlying Logo's development" (p.7).

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Dertouzos, Michael L., and Moses, Joel, eds. The Computer Age: A Twenty-Year View. Cambridge: MIT Press, 1979. A substantial collection; twenty chapters from the likes of Negroponte, Winograd, Simon, Noyce, Minsky, and Weizenbaum. Papert's contribution is entitled, 'Computers and Learning', (pp. 73-86). The editors have seen fit to append the following postscript to his paper "...prior technologies such as television were also expected to transform education, an expectation that has largely not been borne out. Weizenbaum's essay claims that the movement led by Dewey and Montessori were hindered not by a lack of a technology but by the institutional nature of the schools. He argues that schools have become prisons of sorts for children and that this issue must be addressed first".

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DiSessa, Andrea A. "Unlearning Aristotelian Physics: A Study of Knowledge-Based Learning". Working Paper 10, Division for Study and Research in Education. MIT, June 1981. A report on explorations in the dynaturtle micro-world by elementary school children and a university undergraduate. To appear in Cognitive Science.

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Goodman, Danny. "Logo: A Language for Children of All Ages". PC Magazine (December 1982), pp. 216-222.

Goodman, William M. "Logo Goes to Camp". Info Age 1(6) (November 1982), pp. 15-20. An introductory survey article in "Canada's Small Systems Magazine" by Logophile (and SIG reporter for the ECOO Newsletter), Bill Goodman.

Hart, Leslie A. "Brain Compatible Teaching". Today's Education 67(4) (Nov./Dec. 1978), pp. 42-45. This article highlights some emerging evidence from brain to research and examines their implication for education. The general thesis presented is that current educational practices are "brain antagonistic".

Herlihy, Peter. "LOGO and the Love of Learning". ECOO Newsletter 3 (1) (February 1982), pp. 47-49. Comments of a sensitive observer who had watched a group of ten-year olds working with LOGO.

Hofstadter, Douglas R. "The Pleasures of Lisp: The Chosen Language of Artificial Intelligence". Scientific American 248(2) (February 1983), pp. 14-28. Hofstadter, in his inimitable way, sets out to bring Lisp to the (Scientifically American) layman; the first of a series of three articles.

Howe, J.A.M., and Ross, P.M., eds. Microcomputers in Secondary Education: Issues and Techniques. New York: Nichols, 1981; London: Kogan Page, 1981. Two of the papers, "Moving LOGO into Mathematics Classroom" by Howe and Ross, (pp. 89-101) and "Re-Learning Mathematics Through LOGO: Helping Student Teachers Who Don't Understand Mathematics" by B. du Boulay, (pp. 69-81), deal explicitly with LOGO.

Howe, J.A.M.; O'Shea, T.; and Plane, F. Teaching Mathematics Through LOGO Programming. Edinburgh: Department of Artificial Intellegence, University of Edinburgh, 1979.

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Kolata, Gina. "Equal Time for Women". Discover (January 1984), pp. 24-27. A discussion of the reasons why girls are not involved in computers to the same extent as boys are. Special efforts that some schools are making to encourage girls to use computers are presented.

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Kreinberg, Nancy, and Stage, Elizabeth. "Equals in Computer Technology". In The Technological Woman, edited by Jan Zimmerman, New York: Praeger Special Studies, 1983, Chap. 28, pp. 251-259. Women have been slow to become involved in the computer technology. The reasons for this and the change that must take place in schools and outside of schools, so that women will have equal access to the computer technology, are discussed. These studies showed that more boys than girls have computers at home, more boys than girls enrol in computer camps and that the majority of the available computer software is perceived as primarily suited for a male audience.

Kurland, D. Midian, and Pea, Roy D. Children's Mental Models of Recursive Logo Programs. Technical Report No. 10; Center for Children and Technology. New York: Bank Street College of Education, 1984. Children with a year of Logo programming were asked to think out loud about the function of some Logo recursive programs, and then to predict, by hand-simulation of the programs, what the graphics turtle would draw when the program was executed.

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Minsky, Martin. "Form and Content in Computer Science". Journal of the Association for Computing Machinery 17(2) (April 1970), pp. 197-215. Professor Minsky was the 1970 recipient of the Turing Award, the highest honour in the field of computer science. Much of Minksy's Turing lecture was given over to a discussion of educational issues. "Education is another area in which the computer scientist has confused form and content, but this time the confusion concerns his professional role. He perceives his principal function to provide programmed machines for use in old and new educational schemes. Well and good, but I believe that he has a more complex responsibility--to work out and communicate models of the process of education itself." (p.205)

MIT, Division for Study and Research in Education, Logo Group. "Bibliography of Logo Memos Available for Distribution", 1982. In the ten years from October 1971 to October 1981, the Logo Group at MIT published some 61 memos. This document describes and gives prices for those memos which are still available (over 50). In addition four books and 15 papers about Logo produced by members of the Logo project are listed. Some of the early memos have been incorporated into later publications (for instance Memo 5 by Papert and Solomon 'Num: A Game Playing Program', February 1972 appears with minor changes in Chapter 6 of Harold Abelson's Manuals, 19, 20) and a few are highly technical, but there are many gems here which are not widely known. Since the office is unable to process purchase orders, memos must be prepaid. The bibliography is available from Logo Group NE43-7th Floor, MIT, 545 Technology Square, Cambridge, MA USA 02139..

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Papert, Seymour. "Teaching Children Thinking". Mathematics Teaching (Spring 1972). The major part of a paper Professor Papert delivered in 1970 at the IFIP Conference on Computer Education in Amsterdam. "Stated more simply, I believe with Dewey, Montessori and Piaget that children learn by doing and by thinking about what they do. And so the fundamental ingredients of educational innovation must be better things to do and better ways to think about oneself doing these things."

Papert Seymour. "Tomorrow's Classrooms?" Times Educational Supplement (5 March 1982), pp. 31-32, 41. The Lead article in a twelve-page TES 'Extra' on 'Schools and Computers'. Papert in a fine, fighting fettle. "Society will be able to face the task of inventing environments in which children can develop as social, loving, honest human beings without distorting this goal by the crudely technical one of stuffing the multiplication tables into their heads." (p.14). The 'Extra' serves as an excellent overview of the contemporary state of educational computing in Britain.

Papert, Seymour; Watt, Daniel; di Sessa, Andrea; and Weir, Sylvia. Final Report of the Brookline LOGO Project Part II: Project Summary and Data analysis. Cambridge: MIT AI Lab, September 1979, AI Memo No.545 LOGO Memo No. 53. Probably the most comprehensive and readable report on children using LOGO. The work of 16 sixth-grade students is analyzed with reference to issues such as learning styles, programming skills, and mathematical and geometric skills and concepts.

Pea, Roy D. Logo Programming and Problam Solving. Technical Report No.12; Center for Children and Technology. New York: Bank Street College of Education, 1983. This paper, presented at the 1983 AERA meeting in Montreal, challenges the assumption that active involvement with Logo automatically assures transfer of problem solving skills in non-programming contexts.

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Sharon, Donna, and Mehler, Audrey. Microcomputers in Teaching and Learning: An Inventory of Canadian Research. Toronto: TVOntario, Office of Development Research, 1985. Completed and on-going research is reported under five categories. In addition to brief abstracts, the authors names and addresses are provided.

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Staples, Betsy. "Turtles and Sprites for the 99/4". Creative Computing 7 (12) (December 1981), pp. 66-70. A review of the TI LOGO system.

Stavely, Tony. "List Processing in Logo". The Computing Teacher 10(4) (December 1982), pp. 43-47. A psychologist does some data base and statistical work with Logo.

Steffin, Sherwin A. "A Challenge to Seymour Papert". Educational Computer Magazine (July/August 1982). The author of this article is Director of Research and Development at Edu-Ware Services. He believes in "systematic assessment of learning needs, careful specification of expected new behaviors, implementation of strategies designed to foster the desired skills and measurement devices to insure that the requisite learning has occurred" (p.36).

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Thornburg, David D. Every Kid's First Book of Robots and Computers. Greensboro, NC: Compute Books, 1982. An introduction to a number of computing ideas via the Bigtrak robot car and "Turtle Tiles".

Thornburg, David D. "Pilot Turtle Geometry". Classroom Computer News 2(4) (March/April 1982), pp. 38-43. An excerpt from a forthcoming book which illustrates the turtle graphics potential of Atari Pilot.

Torrance, Paul. Guiding Creative Talent. Toronto: Prentice-Hall, 1962. The meaning of creative talent and the ways of nurturing it in an educational setting are discussed. The behavioural and intellectual consequences that emerge when creative talent is blocked are examined in considerable detail.

Upitis, Rena. "Logo and the Primary-Junior Pupil: One Student's

First Encounter". The Computing Teacher 10(3) (November 1982), pp. 28-31. A well-documented report of the initial Logo experience of a very bright grade five pupil.

Upitis, Rena. "Turtle Talk: An Annotated Selection of Logo Programs". The Computing Teacher 10(3) (November 1982), pp. 22-27.

Watt, Dan, ed. BYTE 7(8) (August 1982). Logo follows in the footsteps of APL, Pascal, Forth, Lisp and Smalltalk as the focus for a special August issue of BYTE. With major papers by Abelson, Ciarcia, Watt, Lawler, Harvey, Solomon, Goldenberg, and Williams and minor ones by diSessa and White, Bamberger, Higginson, Boecker and Fischer, Leron, Jewson and Pea, Muller and Lemmons, this collection is a landmark. At $3.50 ($2.95 US) this is the best bargain one is ever likely to find in the way of support materials. If you still don't have one, run to your local computer store to see if they have any left in stock.

Watt, Molly. "What is Logo?" Creative Computing 8(10) (October 1982), pp. 112-129. A very substantial (albeit misleadingly titled) paper on what it means to be an effective Logo teacher. Highly recommended. "As Logo teachers our roles will cover a diverse, and perhaps uncomfortable range including demonstrator, teacher/lecturer, teller, time structurer, problem setter, management solver, arbitrator, decision maker, challenger, helper, collaborator, process sharer, question asker, idea extender, observer, documenter, admirer, enjoyer, time provider, technician and model learner." (pp.120).

Weinreb, William. "Problem Solving with Logo: Using Turtle Graphics to Redraw a Design". Byte 7(11) (November 1982), pp. 118-134. POLYSPI put to work to duplicate a classic computer graphics design.

Weir, Sylvia; Russell, Susan Jo; and Valente, Jose A. "Logo: An Approach to Educating Disabled Children". Byte 7 (9) (September 1982), pp. 342-360.

White, Barbara. "Designing Computer Games to Facilitate Learning". AI Technical Report 619. MIT Artificial Intelligence Lab. February 1981. Available from Publications, Rm NE 43-818, MIT AI Lab 545 Technology Square Cambridge MA USA 02139. A slightly revised version of a Ph.D. thesis done in the Department of Electrical Engineering and Computer Science under the supervision of Professor Seymour Papert. The research explored the design of a computer environment for helping physics students learn about Newtonian dynamics.